BUREAU OF RECLAMATION

Long-Term Operation – Biological Assessment

Appendix O – Tributary Habitat Restoration

October 2024

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Appendix O Tributary Habitat Restoration

O.1 Introduction

Tributary habitat restoration appendix to the Public Draft Environmental Impact Statement (EIS) analyses addresses spawning and rearing habitat actions for the Sacramento River, American River, Stanislaus River, Clear Creek, and San Joaquin River. Project activities primarily include side channel and floodplain creation, expansion, and grading, spawning gravel and large cobble additions, and woody material additions.

Reclamation has authorities for habitat restoration, most specifically through the Central Valley Project Improvement Act (CVPIA), Public Law 102-575.

O.2 Initial Alternative Report

O.2.1 Management Questions

The United States Department of the Interior, Bureau of Reclamation's (Reclamation) management questions for the formulation of an alternative include the following.

- Where is habitat a primary factor influencing survival?
- Does habitat restoration increase primary and secondary productivity and improve growth?
- Does habitat restoration provide refuge habitat and improve survival?
- How does habitat restoration affect operations for flood conveyance, water supply, water quality, and/or hydropower?
- Where can connectivity be restored to provide fish access to suitable habitats and reduce potential habitat restoration needs downstream?

O.2.2 Initial Analyses

Reclamation solicited input for the knowledge base paper, *Tributary Habitat Restoration.*

Reclamation completed an exhaustive literature and data review to consider inclusion or exclusion of Sacramento–San Joaquin Delta (Delta) habitat restoration from consideration in alternatives.

O.2.3 Initial Findings

- Decision analyses suggest that tributary habitat-restoration actions, primarily focused on the addition of spawning or perennial rearing habitat in the mainstem Sacramento River and Clear Creek, can address habitat limitations and improve population productivity in these watersheds.
- Restoration of floodplain rearing habitat can result in increased prey resources and greater fish growth, compared to perennially inundated habitat, during periods of flooding. Restoration of perennially inundated habitat, including side-channel habitat, can provide similar prey abundances and fish growth rates to neighboring side channels and mainstem habitat and increase the total amount of suitable habitat available.
- Direct effects of tributary habitat restoration on rearing and migratory survival are poorly understood. However, high densities of fish in restored habitat sites suggest that restored habitat can provide quality rearing habitat for juvenile salmon and steelhead. Furthermore, increasing rearing habitat availability may decrease negative density-dependent effects on growth and outmigration timing.
- Habitat restoration projects that are designed to expand flood conveyance laterally and flood at lower-flow conditions can reduce the river flow required to inundate floodplains, maintain or increase flood conveyance, increase groundwater storage, and potentially increase settling of sediments and riparian vegetation recruitment.
- Expected effects of providing fish access to habitats upstream of existing barriers on reducing the need for downstream habitat restoration are unknown. Preliminary incubation and spawner translocation efforts have been conducted in Battle Creek and upstream of Shasta Reservoir. Temperature conditions for survival of eggs and alevins appear suitable above Shasta in the McCloud River, but may be too high in Battle Creek.

O.3 Performance Metrics

Performance metrics describe criteria that can be measured, estimated, or calculated relevant to informing trade-offs for alternative management actions.

O.3.1 Habitat

- Suitable spawning habitat for salmonids and steelhead
- Suitable rearing habitat for salmonids and steelhead
- Suitable floodplain habitat for salmonids and steelhead

O.3.2 Biological

None.

O.3.3 Water Supply

Water supply metrics consider the possibility of multipurpose beneficial uses of tributary habitat restoration, including the following.

- South-of-Delta agricultural deliveries (average and critical/dry years)
- Sacramento river settlement contractor and CVPIA refuge deliveries
- *Bay-Delta Water Quality Control Plan* (Bay-Delta WQCP) (D-1641) standards (State Water Resources Control Board 2000)

O.3.4 National Environmental Policy Act Resource Areas

Analysis of the range of alternatives, as required by the National Environmental Policy Act is anticipated to describe changes in multiple resource areas. Key resources are anticipated to include: surface water supply, water quality, air quality, aquatic resources, terrestrial biological resources, regional economics, land use and agricultural resources, recreation, cultural resources, hazards and hazardous material, and climate change.

O.4 Method Selection

In spring 2022, Reclamation solicited input for two knowledge base papers, *Central Valley Tributary Habitat Restoration Effects on Salmonid Growth and Survival and Summer and Fall Habitat Management Actions on Delta Smelt Growth and Survival*, included as attachments. Knowledge base papers compile potential datasets, literature, and models for analyzing potential effects from the operation of the Central Valley Project (CVP) and State Water Project (SWP) on species, water supply, and power generation.

O.4.1 Literature

O.4.1.1 History of Habitat Restoration Programs

The multipurpose water legislation, CVPIA, was signed into law on October 30, 1992. Reclamation, in coordination with the U.S. Fish and Wildlife Service (USFWS) and in partnership with other federal, state and local parties, funds and constructs extensive spawning and rearing habitat restoration projects on the CVP rivers and streams below Reclamation-operated dams. More information can be found on Reclamation's webpage at Central Valley Project Improvement Act (CVPIA) | CVP | California-Great Basin | Bureau of Reclamation (usbr.gov).

O.4.1.2 Habitat Restoration by Division

Table O-1 shows historical gravel inputs and percentage of target in tons on the Sacramento, Stanislaus, and American rivers between 1997–2022.

Table O-1. Historical Gravel Inputs and Percentage of Target in Tons on the Sacramento, Stanislaus, and American Rivers, 1997–2022

Year	Sacramento River (10,000 ton target)	% target	Stanislaus River (3,000 ton target)	% target	American River (7,000 ton target)	% target
1997	31,000	310%	2000	67%		0%
1998	23,000	230%	3000	100%		0%
1999	25,000	250%		0%	6,000	86%
2000	32,000	320%	1,300	43%		0%
2001	0	0%	500	17%		0%
2002	15,000	150%	4,000	133%		0%
2003	8,800	88%		0%		0%
2004	8,500	85%	1,200	40%		0%
2005	7200	72%	2500	83%		0%
2006	6,000	60%	2,500	83%		0%
2007	6,000	60%	4,100	137%	0	0%
2008	8,300	83%		0%	7,000	100%
2009	9,900	99%		0%	10,600	151%
2010	5,500	55%		0%	16,000	229%
2011	5,000	50%	5000	167%	20,770	297%
2012	15,000	150%	3000	100%	24,510	350%
2013	14,000	140%		0%	6,000	86%
2014	0	0%	0	0%	10,000	143%
2015	0	0%	8,000	267%	0	0%
2016	32,000	320%			38,700	553%
2017	14,000	140%				
2018	0	0%	0		0	
2019	32,000	320%			22,000	314%
2020	2,000	20%	15,000	500%		
2021	38,000	380%	8,000	267%	23,700	339%
2022	20,000	200%				
TOTAL	**358,200**	**138%**	**60,100**	**95%**	**185,280**	**120%**

Gravel placements in tons (2,000 pounds/ton). Volumes converted using 1.5 tons per cubic yard. Updated through fall 2022.

O.4.2 Stanislaus River

Table O-2. Historical Gravel Injection Amounts (in tons and cubic yards) into the Lower Stanislaus River

Year	Amount (Tons)	Amount (Cubic Yards)	Gravel Injection Location
1994	4605	3,070	
1995	0	0	
1996	0	0	
1997	19,772	13,181	Goodwin Cable Crossing area
1998	6,666	4,444	Goodwin Cable Crossing area
1999	13,000	7,647	18 riffles in lower Stanislaus River (Two-Mile Bar to city of Oakdale)
2000	2,148	1,432	Goodwin Cable Crossing area
2001	732	488	Goodwin Float Tube Pool—helicopter
2002	4,000	2,353	Goodwin Cable Crossing area
2003	0	0	
2004	1,050	700	Goodwin Float Tube Pool—sluice
2005	2,500	1,471	
2006	2,500	1,471	Goodwin Cable Crossing area
2007	17,118	11,412	Lover's Leap
2007	4,100	3,000	Goodwin Cable Crossing area
2008	0	0	Knights Ferry fire station
2009	0	0	
2010	0	0	
2011	5,000	2,941	Goodwin Cable Crossing area
2012	3,000	1,765	Goodwin Float Tube Pool—sluice
2012	13,600	8,000	Main channel and floodplain bench at Honolulu Bar
2013	0	0	
2014	0	0	
2015	7,059	4,706	Goodwin and cable crossing
2017	4,257	2,838	Buttonbush
2018	1,875	1,250	Rodden Road
2020	15,000	10,000	Goodwin Canyon (3000 tons in Float Tube Pool and 12000 tons at Cable Crossing)
TOTAL	**112,982**	**82,169**	

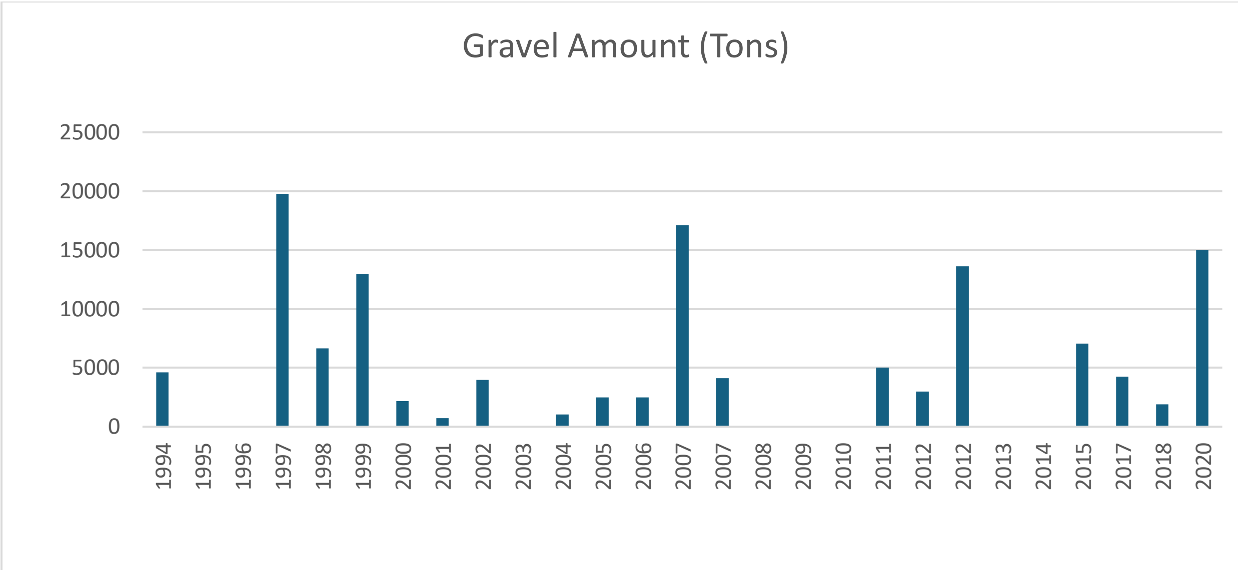


Figure O-1. Historical Gravel Amounts Placed into the Lower Stanislaus River (tons), 1994–2020

O.4.3 Clear Creek

[PLACEHOLDERS:

- Historical gravel inputs
- Historical rearing habitat projects/acreage
- Pre-/post-project monitoring information]

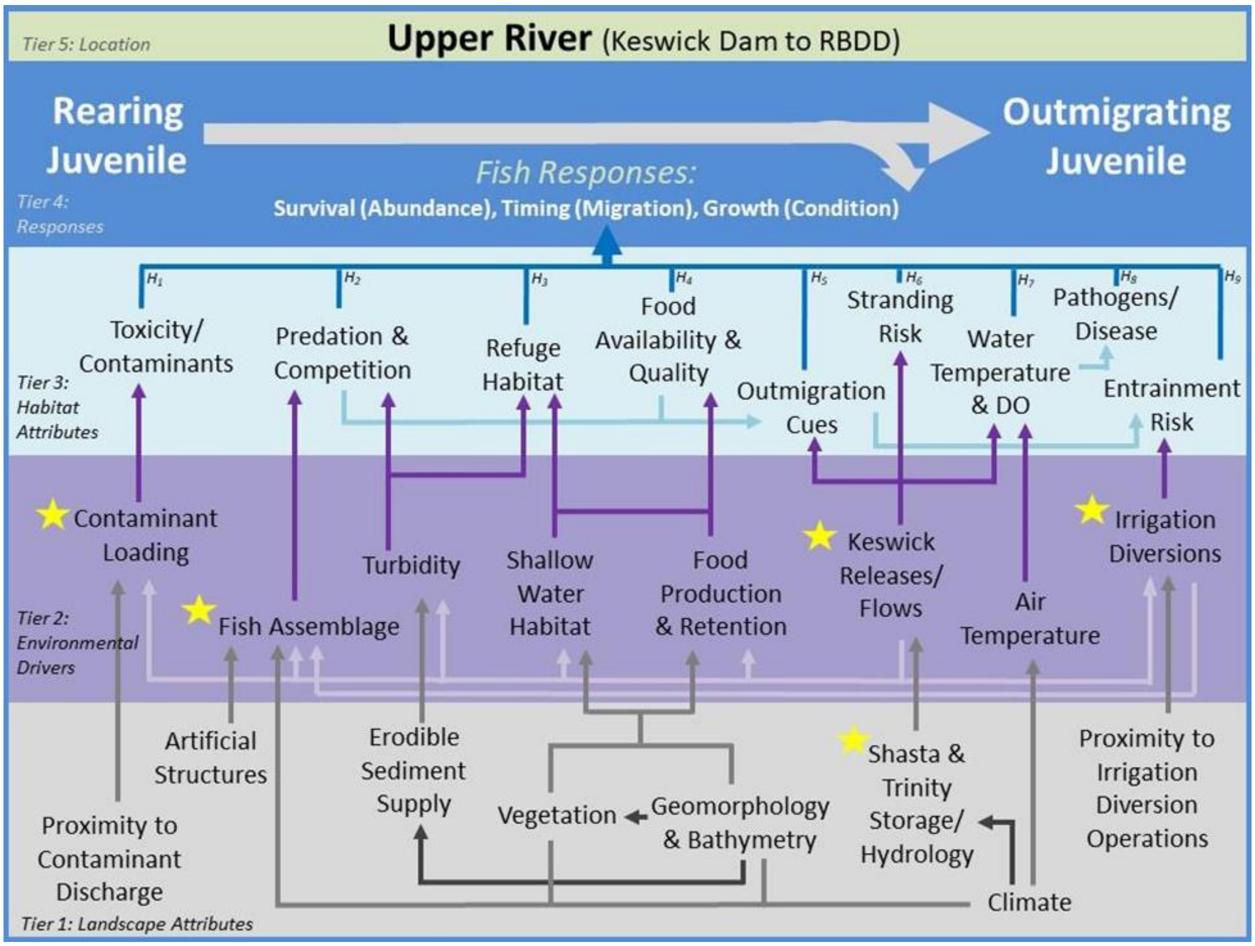
O.4.4 Sacramento River

Upper Sacramento River Anadromous Fish Habitat Restoration Program restoration and monitoring dataset has been used to evaluate the growth, survival, and life-history diversity of juvenile Chinook salmon and steelhead.

- Annual reports – summary of information on what information is in these reports. Fish counts by size comparing suitable and unsuitable habitats.
- There is spawning data but most gravel in placed in one location and the river moves it. Description of suitable habitat.
- Limited pre-project monitoring.
- Monitoring datasets can be found at the Red Bluff Fish and Wildlife Office, USFWS website (doi.net).

O.4.4.1 Chinook Salmon and Steelhead

Tributary habitat restoration can affect the growth, survival, and life-history diversity of Central Valley Chinook salmon. Examples of tributary habitat restoration in the Sacramento River and San Joaquin River basins include creation of new habitat through excavation (e.g., creation of new side channels in the Sacramento River), adding more substrate to existing habitat (e.g., gravel augmentation), and increasing the frequency of floodplain inundation through hydrologic alterations (Bay-Delta Office, Bureau of Reclamation 2021). Figure O-2 provides a conceptual model for effects of habitat conditions on fish responses during the transition from rearing to outmigrating in upper river systems. Tributary habitat restoration is expected to influence aspects of habitat conditions, including turbidity, shallow-water habitat, and food production and retention.



Source: Windell et al. 2017.

Figure O-2. Conceptual Model of Attributes Affecting the Transition of Winter-run Chinook Salmon from Rearing in Upper River Habitats (i.e., in this case, tributaries) to Outmigration

Based on this conceptual model, increasing habitat availability and heterogeneity through restoration has the potential to increase salmon survival by providing refuge habitat from predators and adverse environmental conditions. Potential increases in food production and retention also can positively affect rearing survival.

Habitat restoration can affect juvenile salmon growth as well through effects on food production and retention. For example, creation of new floodplain habitat can increase local growth rates, given observed differences in food production and growth between floodplain and channel habitat (Jeffres et al. 2008). Gravel augmentations also can increase observed macroinvertebrate biomass (Merz and Chan 2005). Constructed side channels can create new food resources capable of being utilized by juvenile salmon (Heady and Merz 2007).

Habitat restoration also can support greater life-history diversity. For example, floodplain habitats have been observed to support greater life-history diversity, based on observations of size variability in the Yolo Bypass as a function of inundation period and temperature variability (Goertler et al. 2017). Habitat restoration can more broadly influence phenotypic and life-history expression by modifying the distribution of resources (Watters et al. 2003).

O.4.5 Datasets

Habitat restoration can have a positive impact on Federally listed native fish species, and its success is influenced by multiple factors, including hydrology, water quality, and fish population abundances and distribution. Monitoring of hydrodynamics, water quality, and fish populations has been ongoing for over forty years, for some datasets, and covers a large spatial extent of many of the Central Valley tributaries. These data and the following plots serve as the foundation and to illustrate patterns of interannual variability in historical hydrology and exports and trends in water quality. They also provide data and visualizations of trends in Federally listed native fish population abundances and distribution.

Presented in this section are three themes of empirical data: hydrodynamics, water quality parameters, and fish observations for Federally listed native fish species. Hydrodynamics datasets (Section O.4.5.1, *Hydrodynamics*) include [Placeholder for datasets]. Water quality parameters (Section O.4.5.2, *Water Quality Parameters*) include [Placeholder for datasets]. Fish observations (Section O.4.5.3, *Fish Observations*) are separated into tributaries. The CVPIA Program has habitat restoration data for Stanislaus, American, Sacramento, and Clear Creek including spawning data (aerial, carcass), otolith and PBT genetics, and spawn weighted usable area (WUA) and redd dewatering.

While some datasets include data gaps or shorter sampling efforts than others, overall, a large body of historic monitoring data within many of the Central Valley tributaries is available. These data sets, in conjunction with modeled data (i.e., CalSim 3, DSM2, USRDOM), serve as inputs for models that can be used to understand and predict the effects of CVP and SWP operations on environmental conditions and fish distributions and loss. Each data set is incorporated into one or multiple lines of evidence used to inform conclusions about both the magnitude and direction of differences among alternatives regarding habitat restoration and listed native fish populations abundance.

O.4.5.1 Hydrodynamics

[Placeholder for datasets]

O.4.5.2 Water Quality Parameters

[Placeholder for datasets]

O.4.5.3 Fish Observations

[Placeholder CVPIA NMFS Report]

O.4.6 American River

Table O-3 shows the annual river-wide Chinook red counts between 2004 and 2020 from aerial spawning surveys.

Table O-3. Annual River-wide Chinook Redd Counts 2004–2020 in the American River from Aerial Spawning Surveys

Water Year	Count
2004	5,309
2005	4,874
2006	2,459
2007	1,206
2008	551
2009	267
2010	526
2011	4,037
2012	5,832
2013	2,840
2014	5,393
2015	2,462
2016	2,463
2017	1,755
2018	3,233
2019	5,644
2020	4,791

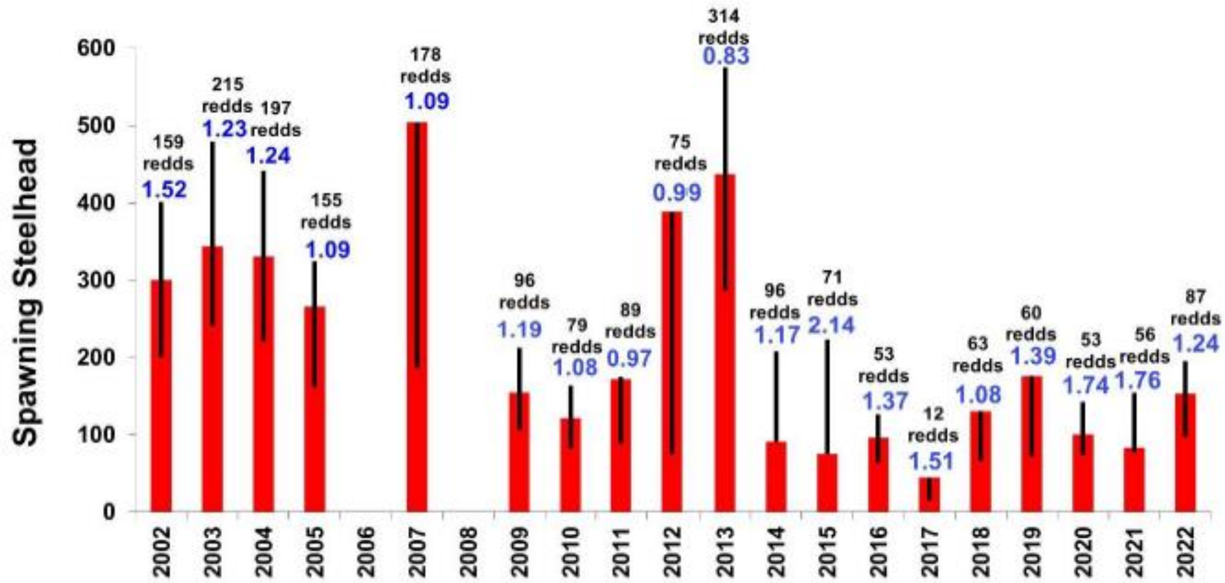
Table O-4. Chinook Redd Data for 2020 in the American River by Location and River Mile. Description of 2nd half of table

Location	River Mile	# Redds
Nimbus Basin	23	1592
Upper Sailor Bar	23/ 22	1168
Lower Sailor Bar	22	662
Upper Sunrise	21	215
Sunrise	20	495
Lower Sunrise	20	438
Sacramento Bar	19	49
El Manto	19	5
El Manto	18	0
Rossmoor Bar	17	42
Ancil Hoffman	17	64
Upper River Bend	15	39
River Bend	14	4
Lower River Bend	13	13
Gristmill	12	3
Sara Park	11	1
Watt Ave	10	1
TOTAL 2020 REDD COUNT		**4791**
Gravel Project Sites:		**# Redds**
Nimbus Basin—Main Channel		926
Nimbus Basin—SC		529
Upper Sailor Bar—2019—Upper Pad		390
Upper Sailor Bar—2019—Lower Pad		521
Upper Sailor Bar—2019—SC		257
Lower Sailor Bar—2012		87
Upper Sunrise—2010		0
Upper Sunrise—2011		21
Sacramento Bar—Main Channel		48
River Bend Park—Main Channel		1
River Bend Park SC		0
2008 Lower Sunrise Side Channel—WF		14
Fry production at 5,000 eggs/female and 30% egg to fry survival		
	Fry	7,186,500

Table O-5. American River Steelhead Redd Counts and Distribution, 2003–2022

Year	Location (river mile in parenthesis)															Total
	Nimbus to Upper Sailor Bar (22)	Lower Sailor Bar to Upper Sunrise (21)	Upper Sunrise to Sunrise Bridge (20)	Sunrise Bridge to Lower Sunrise (19)	Sacramento Bar to San Juan Rapids (18)	San Juan Rapids to Rossmoor (17)	Lower Rossmoor to Ancil Hoffman (16)	Smud Cables to Upper Riverbend (15)	Riverbend Side Channel (14)	Lower River Bend to Arden Rapids (13)	Below River Bend to Gristmill (12)	Gristmill (11)	Gristmill to Watt (10)	Watt (9)	Paradise Beach (5)	
2003	28	46	11	21	16	11	4	22	15	15	5	7	5	9	0	215
2004	31	45	2	21	8	10	2	20	13	6	17	2	0	9	1	187
2005	40	27	6	10	3	0	3	11	5	3	2	3	1	3	14	131
2006	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2007	33	25	9	21	13	18	18	7	3	1	9	1	12	2	0	172
2008	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2009	72	13	5	0	0	0	0	0	0	0	3	0	0	3	0	96
2010	59	0	0	13	0	0	0	0	0	4	2	0	0	1	0	79
2011	32	17	0	2	1	3	9	10	4	0	9	0	0	0	1	88
2012	38	17	6	10	1	1	1	0	0	0	0	0	0	0	1	75
2013	65	118	19	33	11	4	28	2	2	1	21	0	0	12	0	316
2014	21	3	12	4	2	7	1	0	0	21	12	0	1	0	0	84
2015	27	1	5	9	0	19	8	2	0	8	3	1	0	0	0	83
2016	12	8	7	6	1	0	1	1	10	0	4	0	1	1	0	52
2017	0	0	0	1	1	0	1	3	0	4	0	0	0	0	0	10

Year	Location (river mile in parenthesis)															Total
	Nimbus to Upper Sailor Bar (22)	Lower Sailor Bar to Upper Sunrise (21)	Upper Sunrise to Sunrise Bridge (20)	Sunrise Bridge to Lower Sunrise (19)	Sacramento Bar to San Juan Rapids (18)	San Juan Rapids to Rossmoor (17)	Lower Rossmoor to Ancil Hoffman (16)	Smud Cables to Upper Riverbend (15)	Riverbend Side Channel (14)	Lower River Bend to Arden Rapids (13)	Below River Bend to Gristmill (12)	Gristmill (11)	Gristmill to Watt (10)	Watt (9)	Paradise Beach (5)	
2018	5	14	6	5	5	1	5	1	5	5	7	2	0	6	0	67
2019	4	25	6	4	0	4	0	0	2	0	5	0	1	4	5	60
2020	14	4	11	5	5	2	3	2	0	1	0	0	0	4	2	53
2021	3	0	14	2	4	2	6	2	0	8	13	0	0	1	1	56
2022	30	1	13	0	3	0	24	1	6	2	4	0	0	0	3	87



Error estimates are a range of population estimates using either 1 or 2 redds per female. Male to female ratio displayed in blue text above bars. Observed redds displayed in black text ab bottom of bars. 2009 and 2010 estimates based on redd counts only.

Figure O-3. In-River Spawning Steelhead Population Estimates in the American River, 2002–2022

O.4.7 Models

O.4.7.1 Weighted Usable Area (Spawning and Rearing)

WUA analysis provides estimates of the amount of suitable spawning and rearing habitat of fishes available in rivers and streams at various levels of flow (Bovee et al. 1998). WUA is computed as the surface area of physical habitat available weighted by its suitability. Habitat suitability is determined from field studies of the distributions of redds or rearing juveniles with respect to flow velocities, depths, and substrate or cover characteristics in the river (Bovee et al. 1998). These data are used in hydraulic and habitat model simulations (PHABSIM and/or RIVER2D) that estimate the availability of suitable habitat in a portion of the river at a given flow. WUA curves showing suitable habitat availability versus flow are generated from the simulations. These curves are typically used to evaluate effects of proposed changes in a river's flow regime on the river's spawning and rearing habitat availability. The results of the WUA curves can be expressed as the quantity of suitable habitat per unit distance of stream.

Upper Sacramento

Several WUA studies were conducted by USFWS personnel in the upper Sacramento River from 2003 through 2006 (U.S. Fish and Wildlife Service 2003a, 2005a, 2006). The reports of these studies provide spawning WUA curves for winter-run, fall-run, and late fall–run Chinook salmon and steelhead but not spring-run, and rearing WUA for all except steelhead and spring-run. The fall-run WUA curves were used to estimate spring-run spawning and rearing WUA and the late fall-run rearing curves were used to estimate steelhead rearing WUA. The WUA curves were developed for three reaches from Keswick Dam to the Battle Creek (and a reach to Deer Creek for fall-run spawning).

Clear Creek

The USFWS conducted a series of spawning and rearing WUA studies in Clear Creek from 2003 through 2013 for fall-run and spring-run Chinook salmon and steelhead. The reports of these studies (U.S. Fish and Wildlife Service 2007, 2011a, 2011b, 2013, 2015) provide WUA curves for spring-run and steelhead spawning between Whiskeytown Dam and Clear Creek Road (U.S. Fish and Wildlife Service 2007); for fall-run and steelhead spawning between Clear Creek Road and the Sacramento River (U.S. Fish and Wildlife Service 2011a); for spring-run and steelhead rearing between Whiskeytown Dam and Clear Creek Road (U.S. Fish and Wildlife Service 2011b); and for spring-run, fall-run and steelhead rearing between Clear Creek Road and the Sacramento River (U.S. Fish and Wildlife Service 2013).

O.4.7.2 Central Valley Project Improvement Act Science Integration Team Decision Support Model Habitat Modeling

The CVPIA Science Integration Team (SIT) Decision Support Models (DSM) can be used to estimate Chinook salmon spawning and rearing habitat in all CVP tributaries. These estimates are based on flow to suitable habitat area relationships and are largely reported as WUA in square feet per 1000 feet as a function of flow in cubic feet per second (cfs). For some combinations of watershed and run type, estimates of habitat are estimated through varying other means.

For the Clear Creek tributary in-stream spawning, fry, and juvenile habitats of spring-run Chinook salmon are based on relationships determined through four USFWS instream flow evaluations (U.S. Fish and Wildlife Service 2007, 2011a, 2011b, 2013). For Clear Creek floodplain habitat, hydraulic modeling was not available for spring-run Chinook salmon. Instead, floodplain habitat was estimated using a flow to floodplain habitat relationship scaled from the Cottonwood Creek watershed. Based on hydrologic and geomorphic analyses, the floodplain areas for Clear Creek were calculated as 0.21 percent of Cottonwood Creek values. A 0.1 scaling factor was then applied to the high gradient (but not low gradient) extents of the tributary.

For the Upper Sacramento River, in-stream spawning habitats of winter-run Chinook salmon are based on data from a USFWS report on flow-spawning habitat relationships in the Sacramento River (U.S. Fish and Wildlife Service 2003). Winter-run WUAs are based on spawning that occurs between Keswick Dam and Battle Creek and consider conditions with and without the Anderson-Cottonwood Irrigation District (ACID) diversion dam. Instream and floodplain rearing habitats are based on data from the Central Valley Floodplain Evaluation and Delineation HEC-RAS hydraulic model refined for use in the National Marine Fisheries Service (NMFS) winter-run Chinook salmon life cycle model. High quality rearing habitats were defined as areas with channel depth >0.2 m and <1.5 m and velocity ≤0.15m/s. These suitable areas are quantified by the CVPIA SIT DSMs for four segments along the Sacramento River, with the Upper Sacramento defined as Keswick to Red Bluff, which falls within Sections 1 and 2 of the NMFS modeling.

The SIT DSMs use these watershed-specific habitat values in combination with redd and juvenile territory sizes to determine carrying capacity for spawning and rearing. The expected redd size is 9.29 square meters (m^2) based on expert opinion from SIT members. Territory sizes of small (<42 millimeters [mm]), medium (42–72 mm) and large (72–110 mm) are specified as 0.04999, 0.13894, and 0.47108 m^2, respectively, based on analyses in Grant and Kramer (1990).

These models can use CalSim data as inputs for estimates of flow, but not all habitat estimates in the SIT DSMs are solely responsive to flow. Model outputs include estimated habitat areas for spawning and rearing, in which rearing habitat is broken into in-channel and floodplain, as well as spawning and rearing capacity. Detailed model documentation is available online (Home - CVPIA Science Integration Team (gitbook.io)). The model was previously used in a published decision analysis (Peterson and Duarte 2020). The model development is open and participatory.

O.5 Lines of Evidence

O.5.1 Weighted Usable Area (Spawning and Rearing)

This section will summarize results from Attachment O.3, *Sacramento Weighted Usable Area Analysis*, and Attachment O.1, *Clear Creek Weighted Usable Area Analysis*. This line of evidence was used in the Initial Alternatives Report.

O.5.1.1 Biological Assessment Results

The following key takeaways are applicable for all modeled species estimated suitable spawning and rearing habitat. The WUA analyses use the same variables for each species: habitat suitability assessed from field studies of distribution with respect to flow velocities, depths, and substrate/cover and CalSim 3 flows.

- **Driver of Variation:** CalSim 3 flows are the primary driver of variation in WUA analyses. The WUA curves and tables are used to look up the amount of spawning and rearing WUA available at different flows during the corresponding life history periods of the race or species.
- **Calibration and Calibration Method:** Spawning and rearing WUA were estimated for the Biological Assessment modeled scenarios from CalSim 3 flow data for each month of the 100-year period of record. The CalSim 3 operations model used to estimate spawning and rearing WUA under the scenarios employs a monthly timestep. Therefore, the WUA results should be treated as monthly averages. Monthly average WUA results faithfully represent the average conditions affecting the fish. Therefore, using monthly averages to compare WUA results is acceptable for showing differences in the effects of the different flow regimes under baseline and alternatives conditions. Weighting by the weighting factors ensures that the comparisons account for differences in the amount of spawning occurring in each month, improving the validity of the results.

- **Uncertainties:** Species specific WUA curves were not available for each modeled species. In the Sacramento River, fall-run Chinook salmon WUA curves were used to model spring-run spawning and rearing habitat and late fall-run Chinook salmon WUA curves were used to model California Central Valley steelhead rearing habitat. Suitability of physical habitat for salmonids is largely a function of substrate particle size, cover, water depth, and flow velocity. Other unmeasured factors (e.g., flow vortices, water quality, food supply, etc.) could influence habitat suitability, contributing to uncertainty in the results. Furthermore, if channel characteristics have substantially changed since the initial field studies, the shape of the curves might no longer be applicable.
- **Performance Measures:** Outputs of the WUA analyses are an index of habitat suitability, not an absolute measure of habitat surface area. In the literature, WUA is often expressed as square feet, square meters, or acres for a given linear distance of stream, which is misleading and can result in unsupported conclusions (Payne 2003; Railsback 2016; Reiser and Hilgert 2018). For WUA analyses, we recommend looking at the values relative to other scenarios. For the Sacramento River, the results are the means for all years analyzed, weighted by their expected distributions among months of presence and river segments. In Clear Creek, the results are the means for all years analyzed, and combined segments.
    - Winter-run Chinook salmon Sacramento River spawning and rearing habitat WUA values do not vary much among water year types under the three phases of the Proposed Action. This lack of variation suggests the flow ranges in the Proposed Action provide stable spawning habitats in the summer and stable rearing habitats in the late summer and fall. Winter-run spawning WUA in the Sacramento River peaks at relatively low flows. The three phases of the Proposed Action have spawning WUA values higher than the No Action Alternative but are qualitatively similar, as summer flows under the Proposed Action are expected to be slightly lower than flows under the No Action Alternative (see Chapter 4, *Seasonal Operations*, Figure 4-4), when winter-run spawning occurs. The three phases of the Proposed Action have rearing WUA values both above and below the No Action Alternative, as flows in the late-summer and fall during rearing mirror this trend between the scenarios.
    - Spring-run Chinook salmon Sacramento River spawning habitat WUA values are lowest in wet and above normal water year types and highest in the drier water year types under most scenarios, with the exception of Exploratory 1 (EXP1). This difference is attributable to the relatively low flows at which spring-run spawning WUA peaks and the relatively high flows in the Sacramento River. The pattern is reversed in Clear Creek, where relatively low flows occur (see Chapter 4, Figure 4-22), and the spawning habitat WUA values are lowest in critically dry years and highest in wet and above normal water year types. In the Sacramento River, the three phases of the Proposed Action have WUA values both above and below the No Action Alternative, as flows in the fall during spawning mirror this trend between the scenarios. In Clear Creek, the three phases of the Proposed Action have spawning WUA values that are lower than the No Action Alternative values, as flows are potentially higher and slightly closer to peak spawning flow under the No Action Alternative.

- Similar to spawning habitat, spring-run Chinook salmon Sacramento River rearing habitat WUA values are lowest in wet and above normal water year types and highest in the drier water year types across all scenarios. In Clear Creek, the pattern is also reversed for rearing, with the highest WUA values in the wet water year types. The three phases of the Proposed Action have rearing WUA values that are lower than the No Action Alternative in the Sacramento River for fry and juvenile rearing and in Clear Creek for fry rearing. Juvenile rearing WUA values in Clear Creek are higher than values in the No Action Alternative. In Clear Creek, the three phases of the Proposed Action rearing WUA values do not change much across water year types. This suggests the summer flow ranges in the Proposed Action provide stable rearing habitats for juvenile and fry in Clear Creek.
- California Central Valley steelhead Sacramento River spawning habitat WUA values show a similar trend as spring-run and winter-run, with values that are the lowest in wet water years and successively increase in drier years under most scenarios, except EXP1. These differences are attributable to the relatively low flows at which steelhead spawning WUA in the Sacramento River peaks. The pattern is also reversed in Clear Creek, where relatively low flows occur and the spawning habitat WUA values are lowest in critically dry years and highest in wet and above normal water year types. In the Sacramento River, the three phases of the Proposed Action had WUA values qualitatively similar to the No Action Alternative, slightly higher and lower depending on the scenario. Flows in the winter and spring during spawning mirror this trend between the scenarios. In Clear Creek, the three phases of the Proposed Action have spawning WUA values higher than the No Action Alternative.
- Similar to spawning habitat, steelhead Sacramento River rearing habitat WUA values are lowest in wet and above normal water year types and highest in the drier water year types across all scenarios. In Clear Creek, the pattern is also reversed for rearing, with the highest WUA values in the wet water year types. The three phases of the Proposed Action have rearing WUA values that are lower than the No Action Alternative in the Sacramento River for juvenile rearing and in Clear Creek for fry and juvenile rearing. Fry rearing WUA values in the Sacramento River are higher than values in the No Action Alternative.

Winter-run Chinook Salmon

Spawning WUA for winter-run Chinook salmon peaks at approximately 10,000 cfs upstream of Cow Creek, where most winter-run Chinook salmon spawn. The WUA habitat value under the Proposed Action phases range from 522,694 in a above normal year to 583,645 in a critically dry year (Table O-6).

Table O-6. Expected Weighted Usable Area for Winter-run Chinook Spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Three Baseline Scenarios and Three Biological Assessment Modeled Alternative 2 Scenarios

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	503,647	576,192	545,135	548,494	548,607	548,848
Above Normal	477,951	594,047	518,502	522,694	523,507	530,681
Below Normal	469,563	599,138	532,471	538,253	538,289	546,497
Dry	468,443	601,967	547,915	560,634	557,712	564,350
Critical	421,055	598,986	582,871	583,645	578,943	580,022
All	472,251	592,655	545,832	551,576	550,275	554,590

The rearing habitat WUA analysis in the upper Sacramento for winter-run Chinook salmon shows that fry and juvenile rearing habitat generally increases as flows increase, with the greatest quantity and largest variations in the rearing WUA habitat values in the river reach between the ACID Dam and Cow Creek. The rearing WUA habitat values in this reach are lowest at a flow of about 9,000 cfs for fry and at flows between 10,000 cfs and 14,000 cfs for juveniles. The WUA habitat value under the Proposed Action phases ranges from 234,656 in a wet year to 259,957 in a critical year for fry (Table O-7) and from 132,936 in a below normal year to 136,574 in a wet year for juveniles (Table O-8).

Table O-7. Expected Weighted Usable Area for Winter-run Chinook Fry Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Three Baseline Scenarios and Three Biological Assessment Modeled Alternative 2 Scenarios

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	266,854	268,280	235,210	234,984	234,656	234,938
Above Normal	257,580	266,879	237,840	236,715	236,564	236,501
Below Normal	228,209	265,673	254,387	253,464	253,344	252,334
Dry	210,866	264,051	257,409	256,880	257,399	257,864
Critical	188,143	262,792	257,398	259,957	255,456	255,519
All	232,888	265,748	247,838	247,705	246,996	247,008

Table O-8. Expected Weighted Usable Area for Winter-run Chinook Juvenile Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Three Baseline Scenarios and Three Biological Assessment Modeled Alternative 2 Scenarios

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	137,825	141,579	136,563	136,574	136,480	136,502
Above Normal	136,925	136,994	134,859	134,439	134,260	134,429
Below Normal	128,529	136,520	133,640	133,246	133,121	132,936
Dry	129,802	136,889	136,003	135,658	135,872	135,853
Critical	123,629	137,292	135,317	135,360	135,209	135,298
All	131,931	138,215	135,453	135,245	135,200	135,208

Spring-run Chinook Salmon

Spawning WUA for spring-run Chinook salmon, which was estimated from the fall-run WUA curve, peaks at approximately 5,000 cfs upstream of Cow Creek, where most spring-run Chinook salmon spawn. The WUA habitat value under the Proposed Action phases range from 342,214 in wet years to 448,282 in critically dry years (Table O-9).

Table O-9. Expected Weighted Usable Area for Spring-run Chinook Spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Three Baseline Scenarios and Three Biological Assessment Modeled Alternative 2 Scenarios

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	439,130	451,262	340,515	343,070	342,592	342,214
Above Normal	401,963	453,809	359,947	352,226	350,776	352,152
Below Normal	330,606	451,585	429,354	428,824	431,627	430,136
Dry	273,640	452,989	440,725	440,399	441,154	440,956
Critical	247,091	459,597	443,545	448,282	435,218	435,186
All	344,395	453,360	399,692	399,840	398,123	397,909

Spring-run Chinook salmon spawning in Clear Creek occurs between Whiskeytown Reservoir and Clear Creek's confluence with the Sacramento River. Spawning WUA for spring-run Chinook salmon, peaks at approximately 700–900 cfs. The WUA habitat value under the Proposed Action phases range from 4,123 to 5,064 (Table O-10).

Table O-10. Mean Weighted Usable Area for Spring-run Spawning in Clear Creek, Combined Upper Alluvial and Canyon Segments by Water Year Type

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	2,540	5,714	5,752	5,064	5,064	5,064
Above Normal	2,494	5,875	5,643	5,048	5,048	5,048
Below Normal	764	4,170	5,459	4,540	4,561	4,530
Dry	773	3,287	5,719	5,051	5,051	5,051
Critical	563	2,926	5,069	4,141	4,215	4,123
All	1,473	4,430	5,567	4,817	4,832	4,812

The rearing habitat WUA analysis in the upper Sacramento for spring-run Chinook salmon shows that fry and juvenile rearing habitat peaks at lower flows, with the greatest quantity and largest variations in the rearing WUA habitat values in the river reach between the ACID Dam and Cow Creek. Fall-run Chinook salmon rearing WUA habitat values are used as proxies for Sacramento River spring-run Chinook salmon rearing WUA. The fall-run Chinook salmon WUA habitat values for fry and juveniles peak at the minimum flow (3,250 cfs). The WUA habitat value under the Proposed Action phases range from 453,691 to 567,869 for fry rearing (Table O-11). The mean WUA habitat value for juvenile (Yearling) rearing under the Proposed Action phases range from 175,359 in wet water years to 224,786 in critically dry years (Table O-12).

Table O-11. Expected Weighted Usable Area for Spring-run Chinook Fry Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Three Baseline Scenarios and Three Biological Assessment Modeled Alternative 2 Scenarios.

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	416,795	457,583	455,508	453,691	454,147	453,937
Above Normal	413,508	480,525	491,821	489,252	489,809	485,585
Below Normal	416,041	537,650	528,229	523,994	524,594	520,618
Dry	431,463	554,191	549,399	542,669	546,266	544,527
Critical	484,777	595,099	580,491	567,869	565,212	565,304
All	430,544	520,166	516,082	510,841	511,587	509,814

Table O-12. Expected Weighted Usable Area for Spring-run Chinook Juvenile Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Three Baseline Scenarios and Three Biological Assessment Modeled Alternative 2 Scenarios.

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	182,154	183,641	176,621	175,478	175,359	175,491
Above Normal	187,247	192,085	191,772	189,570	188,849	189,116
Below Normal	182,973	209,016	205,613	203,723	203,074	202,858
Dry	192,028	216,519	217,257	214,433	215,220	214,642
Critical	193,690	229,142	226,675	223,881	224,132	224,786
All	187,336	204,369	201,520	199,430	199,407	199,410

Spring-run Chinook salmon rearing in Clear Creek occurs downstream of Whiskeytown releases. Juvenile and fry rearing WUA for spring-run Chinook salmon peaks at approximately 600–900 cfs. The mean WUA habitat value for fry rearing under the Proposed Action phases range from 134,573 in critical water years to 148,763 in wet years (Table O-13). The mean WUA habitat value for juvenile rearing under the Proposed Action phases range from 176,143 in critical water years to 206,168 in wet years (Table O-14).

Table O-13. Mean Weighted Usable Area for Spring-run Fry Rearing in Clear Creek, Combined Lower Alluvial, Upper Alluvial and Canyon Segments by Water Year Type

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	185,685	182,813	140,622	148,763	148,758	148,758
Above Normal	181,031	177,134	137,690	145,540	145,540	145,540
Below Normal	145,477	146,556	134,759	144,090	144,017	144,028
Dry	145,037	142,854	133,683	144,044	144,044	144,044
Critical	112,753	121,738	127,090	134,599	134,589	134,573
All	156,372	156,130	135,326	144,072	144,056	144,055

Table O-14. Mean Weighted Usable Area for Spring-run Juvenile Rearing in Clear Creek, Combined Lower Alluvial, Upper Alluvial and Canyon Segments by Water Year Type

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	231,315	252,978	209,203	206,168	206,168	206,168
Above Normal	230,519	244,602	208,363	205,538	205,538	205,538
Below Normal	194,655	208,445	208,363	205,538	205,538	205,538
Dry	181,157	193,208	206,955	202,898	202,898	202,898
Critical	157,449	155,298	184,309	176,143	177,144	177,655
All	200,748	213,816	204,411	200,378	200,538	200,619

California Central Valley Steelhead

Spawning WUA for steelhead peaks at approximately 3,500 cfs upstream of ACID Dam and at approximately 6,500 cfs between ACID Dam and the Cow Creek confluence, where most steelhead spawn. The WUA habitat value under the Proposed Action phases range from 68,835 in wet years to 120,958 in critically dry years (Table O-15).

Table O-15. Expected Weighted Usable Area for Steelhead Spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Three Baseline Scenarios and Three Biological Assessment Modeled Alternative 2 Scenarios.

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	41,897	68,022	68,940	68,889	68,907	68,835
Above Normal	53,504	82,616	85,350	86,419	86,071	85,715
Below Normal	89,406	112,719	115,190	114,543	114,585	114,042
Dry	98,693	115,715	118,718	118,798	118,827	118,828
Critical	117,244	120,505	120,314	120,229	120,958	120,945
All	77,760	97,954	99,729	99,753	99,841	99,671

Spawning WUA for steelhead peaks around 300 cfs for the Upper and Lower Alluvial segments. Flows may decrease in Clear Creek during winter and spring seasonal operations of Whiskeytown Reservoir and increase the total spawning habitat available for steelhead. The WUA habitat value under the Proposed Action phases range from 38,618 in critically dry years to 43,452 in wet years (Table O-16).

Table O-16. Mean Weighted Usable Area for Steelhead Spawning in Clear Creek, Combined Lower Alluvial, Upper Alluvial and Canyon Segments by Water Year Type

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	35,270	35,662	41,196	43,452	43,452	43,452
Above Normal	35,517	36,262	41,305	43,489	43,489	43,489
Below Normal	32,763	35,167	40,891	43,288	43,295	43,289
Dry	34,675	37,190	39,588	42,470	42,470	42,470
Critical	28,227	30,931	36,610	38,618	38,618	38,618
All	33,584	35,267	40,037	42,418	42,420	42,419

The WUA analyses for steelhead fry and juvenile rearing are assessed downstream of Keswick releases to the Battle Creek confluence. Late fall-run Chinook salmon rearing WUA habitat values are used as proxies for Sacramento River steelhead rearing WUA. The late fall-run Chinook salmon WUA habitat values for both fry and juveniles peak at the minimum flow (3,250 cfs). The WUA habitat value under the Proposed Action phases ranges from 368,182 to 415,011 for fry (Table O-17) and from 652,251 to 816,218 for juveniles (Table O-18). Overall, these WUA habitat values are lowest in wet and above normal water years and successively increase in the drier water year types. This pattern of variation is attributable to the low flows at which steelhead rearing WUA habitat values peak in the Sacramento River.

Table O-17. Expected Weighted Usable Area for Steelhead Fry Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Three Baseline Scenarios and Three Biological Assessment Modeled Alternative 2 Scenarios.

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	517,053	429,915	369,731	369,270	369,217	369,514
Above Normal	532,254	412,169	370,176	370,052	369,569	368,182
Below Normal	524,923	399,469	379,819	377,485	378,388	375,573
Dry	506,445	397,856	383,413	381,072	382,286	383,068
Critical	500,494	400,888	395,872	415,011	412,754	411,061
All	515,476	409,637	379,021	380,946	380,961	380,262

Table O-18. Expected Weighted Usable Area for Steelhead Juvenile Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Three Baseline Scenarios and Three Biological Assessment Modeled Alternative 2 Scenarios

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	169,059	170,656	164,114	163,190	163,063	163,166
Above Normal	173,183	176,981	176,458	174,604	174,015	174,225
Below Normal	168,711	191,453	188,133	186,665	186,134	185,880
Dry	176,487	197,392	197,910	195,623	196,298	195,845
Critical	176,722	207,617	205,617	203,335	203,506	204,054
All	172,688	187,459	184,750	183,055	183,030	183,024

The WUA analyses for steelhead fry and juvenile rearing in Clear Creek are assessed for the three segments downstream of Whiskeytown Reservoir releases. Fry and juvenile rearing WUA for steelhead peaks at approximately 600–900 cfs. The mean WUA habitat value under the Proposed Action phases ranges from 87,375 in critical water years to 88,538 in wet years (Table O-19 and Table O-20).

Table O-19. Mean Weighted Usable Area for Steelhead Fry Rearing in Clear Creek, Combined Lower Alluvial, Upper Alluvial and Canyon Segments by Water Year Type

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	103,078	101,495	88,993	88,538	88,538	88,538
Above Normal	102,954	100,028	88,425	87,994	87,994	87,994
Below Normal	94,135	89,982	88,095	87,994	87,994	87,994
Dry	93,406	90,963	87,185	87,818	87,818	87,818
Critical	86,196	84,587	86,766	86,337	86,375	86,375
All	96,429	93,985	87,962	87,839	87,845	87,845

Table O-20. Mean Weighted Usable Area for Steelhead Juvenile Rearing in Clear Creek, Combined Lower Alluvial, Upper Alluvial and Canyon Segments by Water Year Type

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Wet	192,931	254,577	237,237	222,263	222,247	222,247
Above Normal	181,198	245,210	232,940	220,041	220,041	220,041
Below Normal	127,122	202,905	229,783	213,121	212,171	211,988
Dry	119,511	176,737	235,731	220,420	220,420	220,420

Water Year Type	EXP1	EXP3	NAA	Alt2woTUCP woVA	Alt2woTUCP DeltaVA	Alt2woTUCP AllVA
Critical	100,134	144,778	209,260	190,231	190,605	190,750
All	146,974	207,715	230,456	214,739	214,623	214,613

O.5.1.2 Environmental Impact Statement Results

[EIS key takeaways and narratives to be developed]

Winter-run Chinook Salmon

[narrative for WRC spawning Sac]

Table O-21a. Expected Weighted Usable Area for Winter-run Chinook Spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	545,135	547,715	548,572	548,494	548,607	548,848	543,711	548,569
Above Normal	518,502	511,277	522,731	522,694	523,507	530,681	547,419	522,906
Below Normal	532,471	527,984	538,123	538,253	538,289	546,497	554,780	534,410
Dry	547,915	549,027	561,083	560,634	557,712	564,350	552,224	558,365
Critical	582,871	578,374	582,443	583,645	578,943	580,022	581,003	585,336
All	545,832	544,283	551,495	551,576	550,275	554,590	554,232	550,661

Table O-21b. Expected Weighted Usable Area for Winter-run Chinook Spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	545,135	0.47	0.63	0.62	0.64	0.68	-0.26	0.63
Above Normal	518,502	-1.39	0.82	0.81	0.97	2.35	5.58	0.85
Below Normal	532,471	-0.84	1.06	1.09	1.09	2.63	4.19	0.36
Dry	547,915	0.20	2.40	2.32	1.79	3.00	0.79	1.91
Critical	582,871	-0.77	-0.07	0.13	-0.67	-0.49	-0.32	0.42
All	545,832	-0.28	1.04	1.05	0.81	1.60	1.54	0.88

[narrative for WRC rearing Sac]

Table O-22a. Expected Weighted Usable Area for Winter-run Chinook Fry Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	235,210	237,442	234,968	234,984	234,656	234,938	240,093	234,997
Above Normal	237,840	245,321	236,761	236,715	236,564	236,501	242,387	236,813
Below Normal	254,387	251,034	253,021	253,464	253,344	252,334	257,933	252,214
Dry	257,409	256,959	256,873	256,880	257,399	257,864	259,847	257,277
Critical	257,398	253,475	263,028	259,957	255,456	255,519	262,727	262,259
All	247,838	248,220	248,095	247,705	246,996	247,008	251,909	247,946

Table O-22b. Expected Weighted Usable Area for Winter-run Chinook Fry Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	235,210	0.95	-0.10	-0.10	-0.24	-0.12	2.08	-0.09
Above Normal	237,840	3.15	-0.45	-0.47	-0.54	-0.56	1.91	-0.43
Below Normal	254,387	-1.32	-0.54	-0.36	-0.41	-0.81	1.39	-0.85
Dry	257,409	-0.17	-0.21	-0.21	0.00	0.18	0.95	-0.05
Critical	257,398	-1.52	2.19	0.99	-0.75	-0.73	2.07	1.89
All	247,838	0.15	0.10	-0.05	-0.34	-0.33	1.64	0.04

Table O-23a. Expected Weighted Usable Area for Winter-run Chinook Juvenile Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	136,563	136,945	136,582	136,574	136,480	136,502	137,149	136,587
Above Normal	134,859	135,568	134,399	134,439	134,260	134,429	135,149	134,599
Below Normal	133,640	133,516	133,217	133,246	133,121	132,936	133,037	133,030
Dry	136,003	136,234	135,643	135,658	135,872	135,853	135,789	135,874
Critical	135,317	135,259	136,207	135,360	135,209	135,298	136,203	136,324
All	135,453	135,691	135,360	135,245	135,200	135,208	135,635	135,431

Table O-23b. Expected Weighted Usable Area for Winter-run Chinook Juvenile Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	136,563	0.28	0.01	0.01	-0.06	-0.04	0.43	0.02
Above Normal	134,859	0.53	-0.34	-0.31	-0.44	-0.32	0.21	-0.19
Below Normal	133,640	-0.09	-0.32	-0.29	-0.39	-0.53	-0.45	-0.46
Dry	136,003	0.17	-0.26	-0.25	-0.10	-0.11	-0.16	-0.09
Critical	135,317	-0.04	0.66	0.03	-0.08	-0.01	0.66	0.74
All	135,453	0.18	-0.07	-0.15	-0.19	-0.18	0.13	-0.02

Spring-run Chinook Salmon

[narrative spring-run spawning Sac]

Table O-24a. Expected Weighted Usable Area for Spring-run Chinook Spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	340,515	359,262	343,188	343,070	342,592	342,214	355,495	343,198
Above Normal	359,947	415,812	352,157	352,226	350,776	352,152	380,542	352,056
Below Normal	429,354	424,073	427,272	428,824	431,627	430,136	418,510	427,753
Dry	440,725	439,070	440,393	440,399	441,154	440,956	434,659	440,213
Critical	443,545	431,449	456,308	448,282	435,218	435,186	451,937	457,579
All	399,692	409,562	400,832	399,840	398,123	397,909	404,640	401,066

Table O-24b. Expected Weighted Usable Area for Spring-run Chinook Spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	340,515	5.51	0.78	0.75	0.61	0.50	4.40	0.79
Above Normal	359,947	15.52	-2.16	-2.14	-2.55	-2.17	5.72	-2.19
Below Normal	429,354	-1.23	-0.48	-0.12	0.53	0.18	-2.53	-0.37
Dry	440,725	-0.38	-0.08	-0.07	0.10	0.05	-1.38	-0.12
Critical	443,545	-2.73	2.88	1.07	-1.88	-1.88	1.89	3.16
All	399,692	2.47	0.29	0.04	-0.39	-0.45	1.24	0.34

[narrative spring-run spawning CC]

Table O-25a. Expected Weighted Usable Area for Spring-run Chinook Spawning in Clear Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	5,752	1,200	5,064	5,064	5,064	5,064	4,532	5,046
Above Normal	5,643	1,191	5,048	5,048	5,048	5,048	4,525	5,030
Below Normal	5,459	1,134	4,993	4,540	4,561	4,530	4,457	4,766
Dry	5,719	1,200	5,051	5,051	5,051	5,051	4,526	5,033
Critical	5,069	1,017	4,577	4,141	4,215	4,123	4,184	4,516
All	5,567	1,158	4,968	4,817	4,832	4,812	4,461	4,905

Table O-25b. Expected Weighted Usable Area for Spring-run Chinook Spawning in Clear Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	5,752	-79.13	-11.96	-11.96	-11.96	-11.96	-21.21	-12.28
Above Normal	5,643	-78.89	-10.54	-10.54	-10.54	-10.54	-19.81	-10.87
Below Normal	5,459	-79.23	-8.53	-16.84	-16.44	-17.02	-18.35	-12.68
Dry	5,719	-79.01	-11.68	-11.68	-11.68	-11.68	-20.85	-12.00
Critical	5,069	-79.93	-9.71	-18.30	-16.85	-18.67	-17.46	-10.91
All	5,567	-79.20	-10.75	-13.47	-13.19	-13.56	-19.87	-11.88

[narrative spring-run rearing in Sac]

Table O-26a. Expected Weighted Usable Area for Spring-run Chinook Fry Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	455,508	459,294	453,553	453,691	454,147	453,937	451,157	455,905
Above Normal	491,821	489,832	488,294	489,252	489,809	485,585	484,558	492,029
Below Normal	528,229	519,813	523,923	523,994	524,594	520,618	530,257	523,900
Dry	549,399	542,581	541,788	542,669	546,266	544,527	553,984	545,807
Critical	580,491	568,482	579,203	567,869	565,212	565,304	577,040	576,456
All	516,082	511,765	512,255	510,841	511,587	509,814	514,811	513,976

Table O-26b. Expected Weighted Usable Area for Spring-run Chinook Fry Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	455,508	0.83	-0.43	-0.40	-0.30	-0.34	-0.96	0.09
Above Normal	491,821	-0.40	-0.72	-0.52	-0.41	-1.27	-1.48	0.04
Below Normal	528,229	-1.59	-0.82	-0.80	-0.69	-1.44	0.38	-0.82
Dry	549,399	-1.24	-1.39	-1.23	-0.57	-0.89	0.83	-0.65
Critical	580,491	-2.07	-0.22	-2.17	-2.63	-2.62	-0.59	-0.70
All	516,082	-0.84	-0.74	-1.02	-0.87	-1.21	-0.25	-0.41

Table O-27a. Expected Weighted Usable Area for Spring-run Chinook Juvenile Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	176,621	177,085	175,420	175,478	175,359	175,491	178,542	176,308
Above Normal	191,772	193,605	188,962	189,570	188,849	189,116	191,760	190,139
Below Normal	205,613	205,328	203,557	203,723	203,074	202,858	203,781	202,808
Dry	217,257	217,108	214,448	214,433	215,220	214,642	214,799	215,985
Critical	226,675	225,580	225,044	223,881	224,132	224,786	222,811	224,606
All	201,520	201,681	199,471	199,430	199,407	199,410	200,552	200,065

Table O-27b. Expected Weighted Usable Area for Spring-run Chinook Juvenile Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	176,621	0.26	-0.68	-0.65	-0.71	-0.64	1.09	-0.18
Above Normal	191,772	0.96	-1.47	-1.15	-1.52	-1.38	-0.01	-0.85
Below Normal	205,613	-0.14	-1.00	-0.92	-1.23	-1.34	-0.89	-1.36
Dry	217,257	-0.07	-1.29	-1.30	-0.94	-1.20	-1.13	-0.59
Critical	226,675	-0.48	-0.72	-1.23	-1.12	-0.83	-1.70	-0.91
All	201,520	0.08	-1.02	-1.04	-1.05	-1.05	-0.48	-0.72

[narrative spring-run rearing in CC]

Table O-28a. Expected Weighted Usable Area for Spring-run Chinook Fry Rearing in Clear Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	28,124	25,959	29,758	29,753	29,752	29,752	29,716	29,838
Above Normal	27,538	25,346	29,108	29,108	29,108	29,108	29,090	29,208
Below Normal	26,952	24,942	28,880	28,818	28,803	28,806	28,842	28,971
Dry	26,737	25,347	28,809	28,809	28,809	28,809	28,764	28,874
Critical	25,418	24,500	26,928	26,920	26,918	26,915	27,116	27,007
All	27,065	25,310	28,828	28,814	28,811	28,811	28,827	28,910

Table O-28b. Expected Weighted Usable Area for Spring-run Chinook Fry Rearing in Clear Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	28,124	-7.70	5.81	5.79	5.79	5.79	5.66	6.09
Above Normal	27,538	-7.96	5.70	5.70	5.70	5.70	5.64	6.07
Below Normal	26,952	-7.46	7.16	6.92	6.87	6.88	7.01	7.49
Dry	26,737	-5.20	7.75	7.75	7.75	7.75	7.58	8.00
Critical	25,418	-3.61	5.94	5.91	5.90	5.89	6.68	6.25
All	27,065	-6.48	6.51	6.46	6.45	6.45	6.51	6.81

Table O-29a. Expected Weighted Usable Area for Spring-run Juvenile Rearing in Clear Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	34,937	15,380	34,430	34,430	34,430	34,430	34,806	34,516
Above Normal	34,797	15,121	34,325	34,325	34,325	34,325	34,706	34,412
Below Normal	34,797	15,121	34,325	34,325	34,325	34,325	34,706	34,412
Dry	34,561	15,121	33,884	33,884	33,884	33,884	34,230	33,962
Critical	30,780	14,885	29,554	29,416	29,583	29,668	29,165	29,633
All	34,137	15,156	33,485	33,463	33,490	33,503	33,733	33,568

Table O-29b. Expected Weighted Usable Area for Spring-run Juvenile Rearing in Clear Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	34,937	-50.63	-1.31	-1.31	-1.31	-1.31	-0.34	-1.09
Above Normal	34,797	-51.11	-1.23	-1.23	-1.23	-1.23	-0.24	-1.00
Below Normal	34,797	-60.53	-1.45	-1.45	-1.45	-1.45	-0.28	-1.18
Dry	34,561	-64.26	-2.24	-2.24	-2.24	-2.24	-1.09	-1.98
Critical	30,780	-60.45	-4.66	-5.19	-4.55	-4.23	-6.14	-4.36
All	34,137	-56.62	-1.94	-2.01	-1.93	-1.89	-1.20	-1.70

California Central Valley Steelhead

[narrative steelhead spawning in the Sac]

Table O-30a. Expected Weighted Usable Area for Steelhead Spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	68,940	68,257	68,872	68,889	68,907	68,835	68,905	68,974
Above Normal	85,350	83,628	85,338	86,419	86,071	85,715	85,383	85,113
Below Normal	115,190	113,671	114,540	114,543	114,585	114,042	115,340	114,529
Dry	118,718	118,760	118,804	118,798	118,827	118,828	119,787	118,762
Critical	120,314	121,510	119,788	120,229	120,958	120,945	121,177	120,064
All	99,729	99,225	99,528	99,753	99,841	99,671	100,145	99,557

Table O-30b. Expected Weighted Usable Area for Steelhead Spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	68,940	-0.99	-0.10	-0.07	-0.05	-0.15	-0.05	0.05
Above Normal	85,350	-2.02	-0.01	1.25	0.85	0.43	0.04	-0.28
Below Normal	115,190	-1.32	-0.56	-0.56	-0.53	-1.00	0.13	-0.57
Dry	118,718	0.04	0.07	0.07	0.09	0.09	0.90	0.04
Critical	120,314	0.99	-0.44	-0.07	0.54	0.52	0.72	-0.21
All	99,729	-0.51	-0.20	0.02	0.11	-0.06	0.42	-0.17

[narrative steelhead spawning in CC]

Table O-31a. Expected Weighted Usable Area for Steelhead Spawning in Clear Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	41,196	15,690	43,452	43,452	43,452	43,452	43,515	43,451
Above Normal	41,305	14,393	43,489	43,489	43,489	43,489	43,572	43,489
Below Normal	40,891	14,338	43,611	43,288	43,295	43,289	43,688	43,589
Dry	39,588	14,479	42,470	42,470	42,470	42,470	42,512	42,469
Critical	36,610	13,957	38,610	38,618	38,618	38,618	38,594	38,610
All	40,037	14,697	42,475	42,418	42,420	42,419	42,526	42,471

Table O-31b. Expected Weighted Usable Area for Steelhead Spawning in Clear Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	41,196	-72.32	6.40	6.40	6.40	6.40	6.58	6.39
Above Normal	41,305	-75.77	6.15	6.15	6.15	6.15	6.38	6.15
Below Normal	40,891	-81.05	8.30	7.31	7.34	7.32	8.54	8.23
Dry	39,588	-72.41	8.31	8.31	8.31	8.31	8.43	8.31
Critical	36,610	-80.25	7.09	7.11	7.11	7.11	7.03	7.09
All	40,037	-75.45	7.26	7.09	7.10	7.09	7.41	7.25

[narrative steelhead rearing in the Sac]

Table O-32a. Expected Weighted Usable Area for Steelhead Fry Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	369,731	369,951	369,257	369,270	369,217	369,514	376,385	369,261
Above Normal	370,176	377,065	370,059	370,052	369,569	368,182	371,535	370,069
Below Normal	379,819	375,275	376,446	377,485	378,388	375,573	382,589	376,785
Dry	383,413	380,264	380,896	381,072	382,286	383,068	388,407	380,574
Critical	395,872	395,783	418,908	415,011	412,754	411,061	418,050	411,478
All	379,021	378,472	381,336	380,946	380,961	380,262	386,317	380,136

Table O-32b. Expected Weighted Usable Area for Steelhead Fry Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	369,731	0.06	-0.13	-0.12	-0.14	-0.06	1.80	-0.13
Above Normal	370,176	1.86	-0.03	-0.03	-0.16	-0.54	0.37	-0.03
Below Normal	379,819	-1.20	-0.89	-0.61	-0.38	-1.12	0.73	-0.80
Dry	383,413	-0.82	-0.66	-0.61	-0.29	-0.09	1.30	-0.74
Critical	395,872	-0.02	5.82	4.83	4.26	3.84	5.60	3.94
All	247,838	0.15	0.10	-0.05	-0.34	-0.33	1.64	0.04

Table O-33a. Expected Weighted Usable Area for Steelhead Juvenile Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	164,114	164,551	163,146	163,190	163,063	163,166	165,783	163,881
Above Normal	176,458	177,999	174,141	174,604	174,015	174,225	176,511	175,097
Below Normal	188,133	188,009	186,549	186,665	186,134	185,880	186,435	185,951
Dry	197,910	197,849	195,606	195,623	196,298	195,845	195,894	196,900
Critical	205,617	204,775	204,251	203,335	203,506	204,054	202,427	204,063
All	184,750	184,946	183,086	183,055	183,030	183,024	183,952	183,610

Table O-33b. Expected Weighted Usable Area for Steelhead Juvenile Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	164,114	0.27	-0.59	-0.56	-0.64	-0.58	1.02	-0.14
Above Normal	176,458	0.87	-1.31	-1.05	-1.38	-1.27	0.03	-0.77
Below Normal	188,133	-0.07	-0.84	-0.78	-1.06	-1.20	-0.90	-1.16
Dry	197,910	-0.03	-1.16	-1.16	-0.81	-1.04	-1.02	-0.51
Critical	205,617	-0.41	-0.66	-1.11	-1.03	-0.76	-1.55	-0.76
All	184,750	0.11	-0.90	-0.92	-0.93	-0.93	-0.43	-0.62

[narrative steelhead rearing in CC]

Table O-34a. Expected Weighted Usable Area for Steelhead Fry Rearing in Clear Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	17,799	18,788	17,708	17,708	17,708	17,708	17,794	17,822
Above Normal	17,685	18,696	17,599	17,599	17,599	17,599	17,689	17,717
Below Normal	17,619	18,696	17,599	17,599	17,599	17,599	17,689	17,717
Dry	17,437	18,696	17,564	17,564	17,564	17,564	17,639	17,665
Critical	17,353	18,696	17,240	17,267	17,275	17,275	17,382	17,325
All	17,592	18,722	17,563	17,568	17,569	17,569	17,657	17,671

Table O-34b. Expected Weighted Usable Area for Steelhead Fry Rearing in Clear Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	17,799	4.80	-0.44	-0.44	-0.44	-0.44	-0.02	0.11
Above Normal	17,685	4.91	-0.42	-0.42	-0.42	-0.42	0.02	0.16
Below Normal	17,619	5.72	-0.11	-0.11	-0.11	-0.11	0.37	0.52
Dry	17,437	6.74	0.68	0.68	0.68	0.68	1.08	1.22
Critical	17,353	7.79	-0.66	-0.50	-0.45	-0.45	0.17	-0.16
All	17,592	5.86	-0.15	-0.13	-0.12	-0.12	0.34	0.41

Table O-35a. Expected Weighted Usable Area for Steelhead Juvenile Rearing in Clear Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	33,925	17,329	31,792	31,784	31,781	31,781	31,247	31,609
Above Normal	33,310	17,092	31,466	31,466	31,466	31,466	30,961	31,302
Below Normal	32,859	16,682	31,064	30,476	30,340	30,314	30,346	30,736
Dry	33,710	17,267	31,520	31,520	31,520	31,520	31,009	31,355
Critical	29,924	15,632	27,695	27,203	27,257	27,277	27,347	27,717
All	32,955	16,893	30,894	30,708	30,691	30,690	30,363	30,725

Table O-35b. Expected Weighted Usable Area for Steelhead Juvenile Rearing in Clear Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	33,925	-48.92	-6.29	-6.31	-6.32	-6.32	-7.89	-6.83
Above Normal	33,310	-48.69	-5.54	-5.54	-5.54	-5.54	-7.05	-6.03
Below Normal	32,859	-49.23	-5.46	-7.25	-7.66	-7.74	-7.65	-6.46
Dry	33,710	-48.78	-6.50	-6.50	-6.50	-6.50	-8.01	-6.99
Critical	29,924	-47.76	-7.45	-9.09	-8.91	-8.85	-8.61	-7.38
All	32,955	-48.74	-6.25	-6.82	-6.87	-6.87	-7.86	-6.77

Fall-run Chinook Salmon

[narrative fall-run spawning in the Sac]

Table O-36a. Expected Weighted Usable Area for Fall-run Chinook Spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	248,609	251,195	247,735	247,665	246,597	246,813	253,861	248,051
Above Normal	260,323	271,327	257,015	257,011	254,853	255,899	266,848	257,479
Below Normal	279,409	278,724	277,187	277,477	275,880	274,523	272,376	275,650
Dry	282,535	282,309	281,169	281,218	281,931	279,807	281,449	281,806
Critical	295,535	293,889	299,876	295,655	293,366	293,615	300,890	298,829
All	271,162	273,059	270,353	269,760	268,670	268,172	272,874	270,231

Table O-36b. Expected Weighted Usable Area for Fall-run Chinook Spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	248,609	1.04	-0.35	-0.38	-0.81	-0.72	2.11	-0.22
Above Normal	260,323	4.23	-1.27	-1.27	-2.10	-1.70	2.51	-1.09
Below Normal	279,409	-0.25	-0.79	-0.69	-1.26	-1.75	-2.52	-1.35
Dry	282,535	-0.08	-0.48	-0.47	-0.21	-0.97	-0.38	-0.26
Critical	295,535	-0.56	1.47	0.04	-0.73	-0.65	1.81	1.11
All	271,162	0.70	-0.30	-0.52	-0.92	-1.10	0.63	-0.34

[narrative fall-run spawning in CC]

Table O-37a. Expected Weighted Usable Area for Fall-run Chinook Spawning in Clear Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	197,705	114,579	201,120	201,120	201,120	201,120	196,781	201,120
Above Normal	197,705	114,579	201,120	201,120	201,120	201,120	196,781	201,120
Below Normal	192,524	112,033	201,120	197,831	198,023	198,289	196,781	200,941
Dry	197,705	114,579	201,120	201,120	201,120	201,120	196,781	201,120
Critical	136,527	81,290	145,932	142,095	143,601	141,779	154,459	143,347
All	187,596	109,128	192,841	191,674	191,935	191,709	190,432	192,422

Table O-37b. Expected Weighted Usable Area for Fall-run Chinook Spawning in Clear Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	197,705	-68.64	2.82	2.82	2.82	2.82	-0.76	2.82
Above Normal	197,705	-68.09	2.80	2.80	2.80	2.80	-0.76	2.80
Below Normal	192,524	-88.51	9.45	5.84	6.05	6.34	4.68	9.26
Dry	197,705	-88.63	3.64	3.64	3.64	3.64	-0.99	3.64
Critical	136,527	-76.22	12.98	7.68	9.76	7.25	24.74	9.41
All	187,596	-76.95	5.14	4.00	4.25	4.03	2.78	4.73

[narrative fall-run rearing in the Sac]

Table O-38a. Expected Weighted Usable Area for Fall-run Chinook Fry Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	177,821	175,517	176,638	176,841	177,013	176,998	174,415	177,805
Above Normal	229,007	217,392	226,428	229,343	228,862	228,191	219,760	228,283
Below Normal	295,355	289,712	291,889	291,907	290,983	290,331	287,489	291,396
Dry	317,204	316,040	313,453	313,867	314,902	313,433	317,316	315,155
Critical	344,867	345,067	343,041	339,484	344,537	345,060	344,619	341,795
All	266,237	262,621	263,725	263,724	264,592	264,108	262,503	264,457

Table O-38b. Expected Weighted Usable Area for Fall-run Chinook Fry Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	-1.30	-0.67	-0.55	-0.45	-0.46	-1.92	-0.01	-1.30
Above Normal	-5.07	-1.13	0.15	-0.06	-0.36	-4.04	-0.32	-5.07
Below Normal	-1.91	-1.17	-1.17	-1.48	-1.70	-2.66	-1.34	-1.91
Dry	-0.37	-1.18	-1.05	-0.73	-1.19	0.04	-0.65	-0.37
Critical	0.06	-0.53	-1.56	-0.10	0.06	-0.07	-0.89	0.06
All	-1.36	-0.94	-0.94	-0.62	-0.80	-1.40	-0.67	-1.36

Table O-39a. Expected Weighted Usable Area for Fall-run Chinook Juvenile Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	167,061	165,808	166,997	166,986	167,013	167,070	164,405	166,980
Above Normal	173,315	171,758	173,451	173,471	173,501	172,640	171,616	173,477
Below Normal	188,565	185,016	187,349	187,747	188,449	187,141	192,391	187,171
Dry	192,553	190,916	192,941	193,236	193,811	194,576	197,892	192,681
Critical	207,891	203,702	213,653	209,372	207,499	206,366	215,240	211,970
All	184,459	182,188	185,256	184,713	184,689	184,351	186,623	184,891

Table O-39b. Expected Weighted Usable Area for Fall-run Chinook Juvenile Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	167,061	-0.75	-0.04	-0.05	-0.03	0.00	-1.59	-0.05
Above Normal	173,315	-0.90	0.08	0.09	0.11	-0.39	-0.98	0.09
Below Normal	188,565	-1.88	-0.64	-0.43	-0.06	-0.76	2.03	-0.74
Dry	192,553	-0.85	0.20	0.35	0.65	1.05	2.77	0.07
Critical	207,891	-2.02	2.77	0.71	-0.19	-0.73	3.54	1.96
All	184,459	-1.23	0.43	0.14	0.13	-0.06	1.17	0.23

[narrative fall-run rearing in CC]

Table O-40a. Expected Weighted Usable Area for Fall-run Chinook Fry Rearing in Clear Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	38,399	44,136	37,731	37,731	37,731	37,731	37,604	37,731
Above Normal	38,724	44,681	38,052	38,052	38,052	38,052	37,920	38,052
Below Normal	38,798	44,681	38,026	38,030	38,030	38,029	37,894	38,030
Dry	39,323	44,681	38,409	38,409	38,409	38,409	38,299	38,409
Critical	40,349	44,680	39,855	39,855	39,855	39,855	39,832	39,855
All	39,050	44,528	38,332	38,332	38,332	38,332	38,224	38,332

Table O-40b. Expected Weighted Usable Area for Fall-run Chinook Fry Rearing in Clear Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	38,399	16.97	-1.98	-1.98	-1.98	-1.98	-2.35	-1.98
Above Normal	38,724	17.64	-1.99	-1.99	-1.99	-1.99	-2.38	-1.99
Below Normal	38,798	16.69	-2.19	-2.18	-2.18	-2.18	-2.56	-2.18
Dry	39,323	14.36	-2.45	-2.45	-2.45	-2.45	-2.75	-2.45
Critical	40,349	11.43	-1.30	-1.30	-1.30	-1.30	-1.36	-1.30
All	39,050	15.41	-2.02	-2.02	-2.02	-2.02	-2.32	-2.02

Table O-41a. Expected Weighted Usable Area for Fall-run Juvenile Rearing in Clear Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	25,782	18,743	24,900	24,900	24,900	24,900	24,755	24,900
Above Normal	25,782	18,743	24,900	24,900	24,900	24,900	24,755	24,900
Below Normal	25,507	18,535	24,900	24,366	24,366	24,366	24,755	24,633
Dry	25,782	18,743	24,900	24,900	24,900	24,900	24,755	24,900
Critical	24,511	17,753	22,302	21,731	22,070	22,038	22,991	22,452
All	25,529	18,547	24,484	24,297	24,351	24,346	24,473	24,460

Table O-41b. Expected Weighted Usable Area for Fall-run Juvenile Rearing in Clear Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	25,782	-27.30	-3.42	-3.42	-3.42	-3.42	-3.98	-3.42
Above Normal	25,782	-27.30	-3.42	-3.42	-3.42	-3.42	-3.98	-3.42
Below Normal	25,507	-27.34	-2.38	-4.47	-4.47	-4.47	-2.95	-3.43
Dry	25,782	-27.30	-3.42	-3.42	-3.42	-3.42	-3.98	-3.42
Critical	24,511	-27.57	-9.01	-11.34	-9.96	-10.09	-6.20	-8.40
All	25,529	-27.35	-4.09	-4.83	-4.61	-4.63	-4.14	-4.19

Late Fall-run Chinook Salmon

[narrative late fall-run spawning in the Sac]

Table O-42a. Expected Weighted Usable Area for Late Fall-run Chinook Spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	173,702	170,866	171,746	172,176	172,601	172,584	170,001	174,201
Above Normal	226,884	210,084	223,076	226,599	226,173	225,212	213,486	226,719
Below Normal	257,048	253,693	255,025	255,026	254,051	253,848	249,880	254,618
Dry	280,192	277,702	274,627	274,857	276,405	275,625	276,762	277,845
Critical	308,625	306,270	304,982	304,394	308,616	309,708	302,470	304,190
All	243,156	238,310	239,795	240,372	241,296	241,106	237,085	241,600

Table O-42b. Expected Weighted Usable Area for Late Fall-run Chinook Spawning in the Sacramento River from Keswick Dam to the Battle Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	173,702	-1.63	-1.13	-0.88	-0.63	-0.64	-2.13	0.29
Above Normal	226,884	-7.40	-1.68	-0.13	-0.31	-0.74	-5.91	-0.07
Below Normal	257,048	-1.31	-0.79	-0.79	-1.17	-1.24	-2.79	-0.95
Dry	280,192	-0.89	-1.99	-1.90	-1.35	-1.63	-1.22	-0.84
Critical	308,625	-0.76	-1.18	-1.37	0.00	0.35	-1.99	-1.44
All	243,156	-1.99	-1.38	-1.14	-0.76	-0.84	-2.50	-0.64

[narrative late fall-run rearing in the Sac]

Table O-43a. Expected Weighted Usable Area for Late Fall-run Chinook Fry Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	408,175	409,503	407,911	407,907	407,868	407,993	404,002	407,950
Above Normal	413,558	418,974	414,442	413,850	414,305	409,047	413,311	414,684
Below Normal	424,557	423,266	423,934	424,582	426,992	419,988	438,344	423,485
Dry	432,209	425,394	431,906	432,163	433,380	435,731	448,418	431,687
Critical	466,993	450,647	483,744	472,641	463,016	458,930	493,127	475,630
All	427,057	423,703	429,602	427,919	427,158	425,107	436,407	428,215

Table O-43b. Expected Weighted Usable Area for Late Fall-run Chinook Fry Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	408,175	0.33	-0.06	-0.07	-0.08	-0.04	-1.02	-0.06
Above Normal	413,558	1.31	0.21	0.07	0.18	-1.09	-0.06	0.27
Below Normal	424,557	-0.30	-0.15	0.01	0.57	-1.08	3.25	-0.25
Dry	432,209	-1.58	-0.07	-0.01	0.27	0.81	3.75	-0.12
Critical	466,993	-3.50	3.59	1.21	-0.85	-1.73	5.60	1.85
All	427,057	-0.79	0.60	0.20	0.02	-0.46	2.19	0.27

Table O-44a. Expected Weighted Usable Area for Late Fall-run Chinook Juvenile Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence for the Environmental Impact Statement Modeled Baseline Scenario and All Alternatives

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	146,115	145,066	146,404	146,382	146,289	146,525	146,985	146,362
Above Normal	138,604	138,055	138,927	139,000	138,957	140,412	140,532	139,121
Below Normal	136,531	137,398	136,858	137,706	138,187	139,757	139,595	136,582
Dry	141,755	141,398	143,677	143,664	143,393	145,519	140,093	142,919
Critical	158,342	154,956	168,956	165,568	164,259	163,625	165,254	167,397
All	144,248	143,406	146,593	146,204	145,984	146,945	146,020	146,127

Table O-44b. Expected Weighted Usable Area for Late Fall-run Chinook Juvenile Rearing in the Sacramento River from Keswick Dam to the Battle Creek Confluence, Percent Differences of the Alternatives and No Action Alternative

Water Year Type	NAA	Alt1	Alt2 wTUCP woVA	Alt2 woTUCP woVA	Alt2 woTUCP DeltaVA	Alt2 woTUCP AllVA	Alt3	Alt4
Wet	146,115	-0.72	0.20	0.18	0.12	0.28	0.60	0.17
Above Normal	138,604	-0.40	0.23	0.29	0.25	1.30	1.39	0.37
Below Normal	136,531	0.63	0.24	0.86	1.21	2.36	2.24	0.04
Dry	141,755	-0.25	1.36	1.35	1.16	2.65	-1.17	0.82
Critical	158,342	-2.14	6.70	4.56	3.74	3.34	4.37	5.72
All	144,248	-0.58	1.63	1.36	1.20	1.87	1.23	1.30

O.5.2 Central Valley Project Improvement Act Decision Support Models

This section summarizes results from Attachment O.2, *CVPIA SIT DSM habitat Modeling*. This line of evidence was used in the Initial Alternative Report. Results provide an evaluation of the change in the suitable acres for adults spawning and juvenile rearing between the No Action Alternative and each alternative.

- The driver of the CVPIA DSMhabitat model's variation in its results is differences between alternatives in CalSim 3 flow.
- **Calibration:** The DSMhabitat model was run using CalSim 3-modeled flow data from 1922 to 2021. Reference tables and functions for linking flow to habitat estimates were obtained from the DSMhabitat package developed by FlowWest (CVPIA-OSC/DSMhabitat: Habitat estimates for the life cycle models developed by CVPIA's Science Integration Team (github.com))
- Several main uncertainties of this line of evidence should be considered in the weight of evidence of this analysis include that (1) the DSMhabitat model typically uses WUA to determine habitat suitability, an approach which has received critiques but which is still the best quantitative information of habitat availability, as it relates to flow, for selected watersheds (2) the DSMhabitat model uses a fixed, average redd size to calculate spawner abundance capacity, and thus does not account for variation in redd sizes that may affect habitat capacity.
- Habitat varies across watersheds, water year types, and Biological Assessment alternatives. The degree of uncertainty may suggest that differences across water year types and alternatives may not be statistically significant. However, we have characterized some of the coarse trends as follows:
    - Sacramento River, Spawning Habitat
        - In general, EXP1 was less like the No Action Alternative than other alternatives across all watersheds and most water year types.
        - Adult spawning habitat in the Upper Sacramento River for winter-run Chinook salmon is qualitatively similar across water year types, is lower for EXP1 relative to the No Action Alternative but greater for Exploratory 3 (EXP3), and is similar among the No Action Alternative and all four components of Alternative 2 (Figure O-4).
        - Adult spawning habitat in the Upper Sacramento River for spring-run Chinook salmon is qualitatively similar across water year types, but with a slight reduction in above normal and wet years. Median adult spawning habitat values under EXP1 and EXP3 were higher than under the No Action Alternative under above normal and wet water year types, and EXP1 had a lower medians than the No Action Alternative in other water year types; all other alternatives were qualitatively similar to the No Action Alternative (Figure O-5).

    - For steelhead spawning habitat in the Upper Sacramento River, there was considerable uncertainty across water year types, but medians in above normal and wet water year types were generally lower. All alternatives except EXP1 were qualitatively similar to the No Action Alternative; EXP1 was consistently lower (Figure O-6).
    - The pattern of slightly lower adult spawning habitat available in above normal and/or wet water year types is likely due to the general reduction in habitat suitability as releases increase, as the result of bathymetry, increasing depth, and velocity tied to increased discharge.
- Sacramento River, Instream Rearing Habitat
    - A gradual decline in the expected median values of instream rearing habitat in the Sacramento River is observed going from critical to increasingly wet water year types and is greater for EXP1 and EXP3 than the No Action Alternative for most water year types for winter-run Chinook salmon (Figure O-7), spring-run Chinook salmon (Figure O-8) and steelhead (Figure O-9). For winter-run Chinook salmon, Sacramento River instream rearing habitat is slightly less for components of Alternative 2 without Voluntary Agreements than the No Action Alternative for below normal water years; for steelhead Sacramento River instream rearing habitat is slightly less for components of Alternative 2 without Voluntary Agreements than the No Action Alternative for above normal years.
- Sacramento River, Floodplain Rearing Habitat
    - Floodplain rearing habitat in the Upper Sacramento River for all three salmonids shows no discernable differences across water year type, except for infrequent peaks (outliers) in wet water years (Figure O-10 through Figure O-12).
- Clear Creek
    - For adult spawning habitat in Clear Creek for spring-run Chinook salmon, Alternative 2 phases were most similar to the No Action Alternative in critical water year types, and median values were generally lower than the No Action Alternative median in other water year types (Figure O-13). For steelhead, all alternatives except EXP1 and EXP3 were qualitatively similar to the No Action Alternative (Figure O-14).

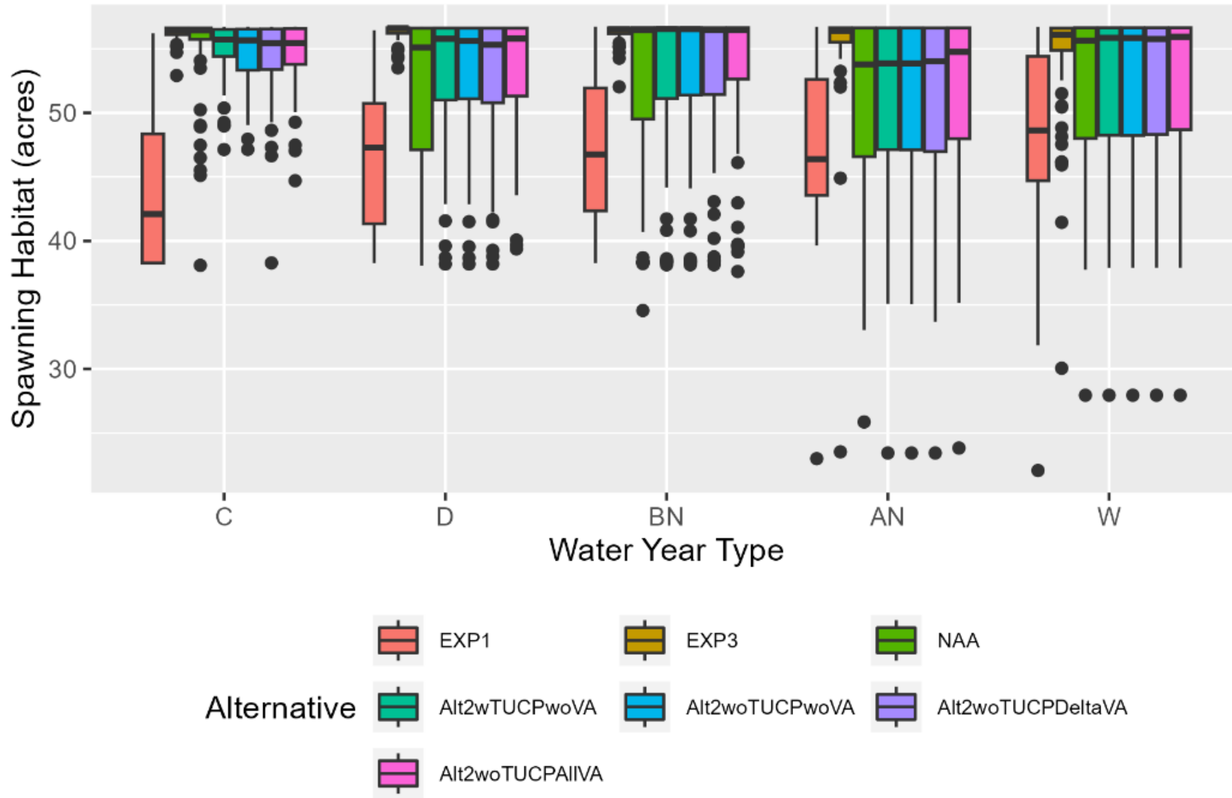
        - Instream rearing habitat in Clear Creek for spring-run Chinook salmon and steelhead increased with increasingly wet water year types (Figure O-15 and Figure O-16). EXP1 and EXP3 showed considerable variation, and median values were generally lower than the No Action Alternative in drier years and higher than the No Action Alternative in wetter water year types. Median values for the Alternative 2 components were generally higher than the No Action Alternative median value except in critical water year types.
        - Floodplain rearing habitat in Clear Creek for spring-run Chinook salmon and steelhead increased with increasingly wet water year types, though with frequent outliers under all alternatives (Figure O-17 and Figure O-18). EXP1 (and to a lesser degree EXP3) showed the greatest variation, and the most dissimilarity from the No Action Alternative. The Alternative 2 components performed qualitatively similar to the No Action Alternative across water year types.
    - Yolo and Sutter Bypasses
        - Rearing habitat for juvenile salmonids in the Yolo and Sutter Bypasses showed a slight increase with increasingly wet water year types. All alternatives performed qualitatively similar to the No Action Alternative (Figure O-19).
- Habitat varies across watersheds, water year types, and EIS alternatives. The degree of uncertainty may suggest that differences across water year types and alternatives may not be statistically significant. However, we have characterized some of the coarse trends as follows:
    - Sacramento River, Spawning Habitat
        - Adult spawning habitat in the Upper Sacramento River for winter-run Chinook salmon is qualitatively similar across water year types and all alternatives, except that Alternative 3 is lower than the No Action Alternative in below normal and dry water year types.
        - Adult spawning habitat in the Upper Sacramento River for spring-run Chinook salmon decreases with increasingly wet water year types and all alternatives were qualitatively similar to the No Action Alternative, though Alternative 1 and Alternative 3 medians were expected to be higher than the No Action Alternative in some water year types.
        - For steelhead spawning habitat in the Upper Sacramento River, there was considerable uncertainty in above normal and wet water year types, but medians in above normal and wet water year types were generally lower than medians in other water year types. All alternatives were qualitatively similar to the No Action Alternative.

    - The pattern of slightly lower adult spawning habitat available in above normal and/or wet water year types is likely due to the general reduction in habitat suitability as releases increase, as the result of bathymetry, increasing depth, and velocity tied to increased discharge.
- Sacramento River, Instream Rearing Habitat
    - A gradual decline in the expected median values of instream rearing habitat in the Sacramento River is observed going from critical to increasingly wet water year types for winter-run Chinook salmon, spring-run Chinook salmon, and steelhead.
    - For winter-run Chinook salmon, Sacramento River instream rearing habitat medians show the greatest amount of variation from the No Action Alternative across the majority of alternatives in below normal water year types, while Alternative 1 and Alternative 3 had higher expected median values than the No Action Alternative in wet water years.
    - Spring-run Chinook salmon instream rearing habitat in the Sacramento River was qualitatively similar to the No Action Alternative across all alternatives and water year types.
    - Steelhead instream rearing habitat in the Sacramento River showed the greatest variation in median values during above normal water year types.
- Sacramento River, Floodplain Rearing Habitat
    - Floodplain rearing habitat in the Upper Sacramento River for winter-run and spring-run Chinook salmon shows no discernable differences across water year type, except for infrequent peaks (outliers) in wet water years (Figure 5.2.2.1.7-8).
    - For steelhead, floodplain rearing habitat in the Sacramento River showed very slight increases with increasingly wet water year types. All alternatives were qualitatively similar to the No Action Alternative, except for Alternative 1, which was consistently lower than the No Action Alternative (Figure 5.2.2.1.9).
- Clear Creek
    - For spring-run Chinook salmon, adult spawning habitat in Clear Creek was fairly consistent across water year types. The No Action Alternative was consistently higher than other alternatives, and Alternative 1 and Alternative 3 were consistently lower than the other alternatives (Figure 5.2.2.2.1).
    - For steelhead, adult spawning habitat in Clear Creek was fairly consistent across water year types. All alternatives except Alternative 1 were more similar to the No Action Alternative (Figure 5.2.2.2.2).

    - Instream rearing habitat in Clear Creek increased with increasingly wet water year types for spring-run Chinook salmon (Figure 5.2.2.2.3) and steelhead (Figure 5.2.2.2.4). Median values of most alternatives were generally greater than the No Action Alternative in all but critical water year types, except for Alternative 1, which was consistently lower than the No Action Alternative.
    - Floodplain rearing habitat in Clear Creek for spring-run Chinook salmon and steelhead increased very slightly with increasingly wet water year types (Figure 5.2.2.2.5-6). All alternatives performed qualitatively similar to the No Action Alternative, with the exception of Alternative 1, which was consistently lower.
    - The pattern of lower habitat available under Alternative 1 in Clear Creek is likely due to the general reduction in habitat suitability when the reservoir is not used for flow regulation.
- Yolo and Sutter Bypasses
    - Rearing habitat for juvenile salmonids in the Yolo and Sutter Bypasses showed a slight increase with increasingly wet water year types. All alternatives performed qualitatively similar to the No Action Alternative (Figure 5.2.2.2.7).

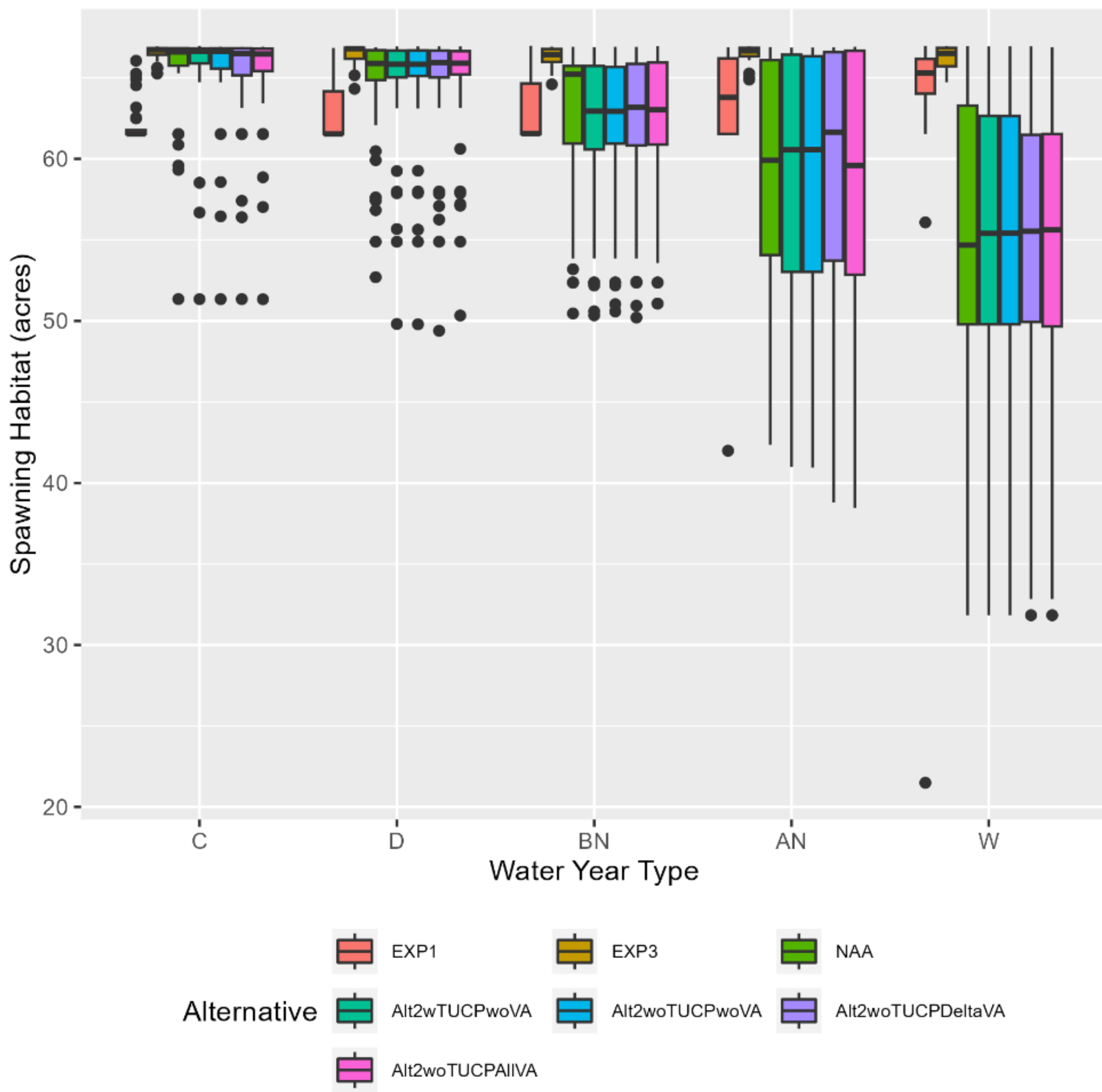
O.5.2.1 Biological Assessment Results

Sacramento River



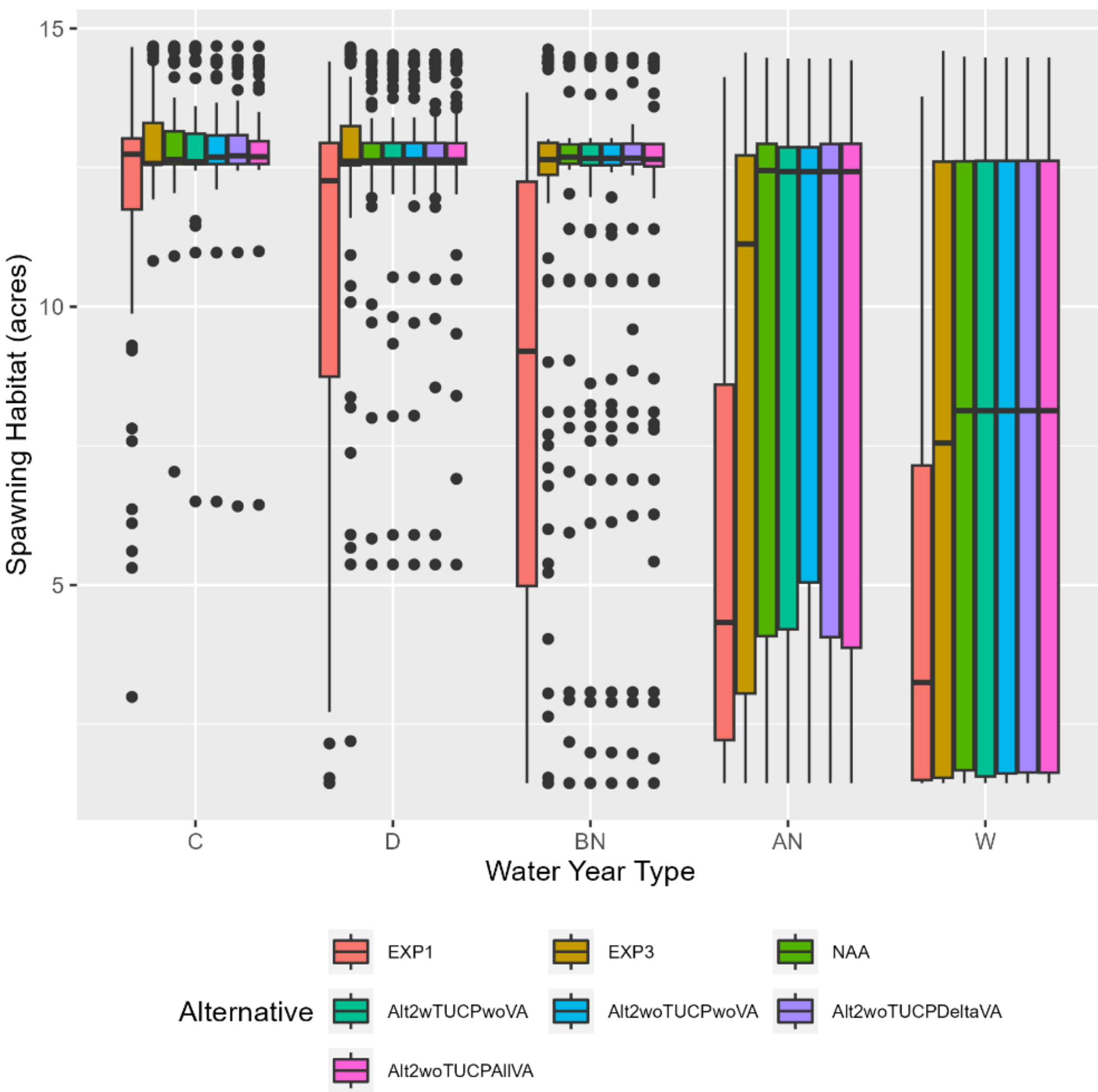
C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-4. Adult Spawning Habitat in the Upper Sacramento River for Winter-run Chinook Salmon Across Water Year Types for the Biological Assessment Alternatives



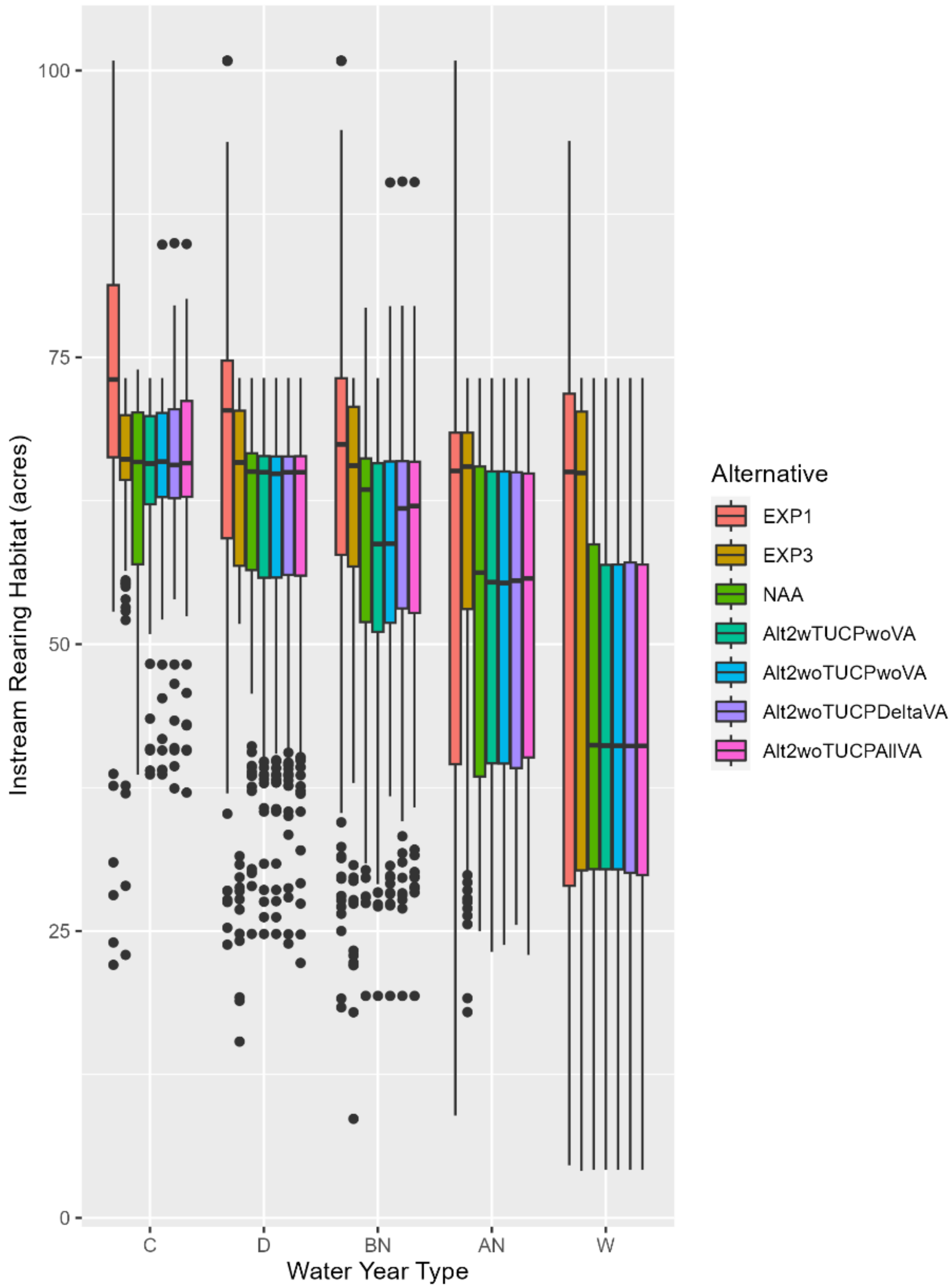
C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-5. Adult Spawning Habitat in the Upper Sacramento River for Spring-run Chinook Salmon Across Water Year Types for the Biological Assessment Alternatives



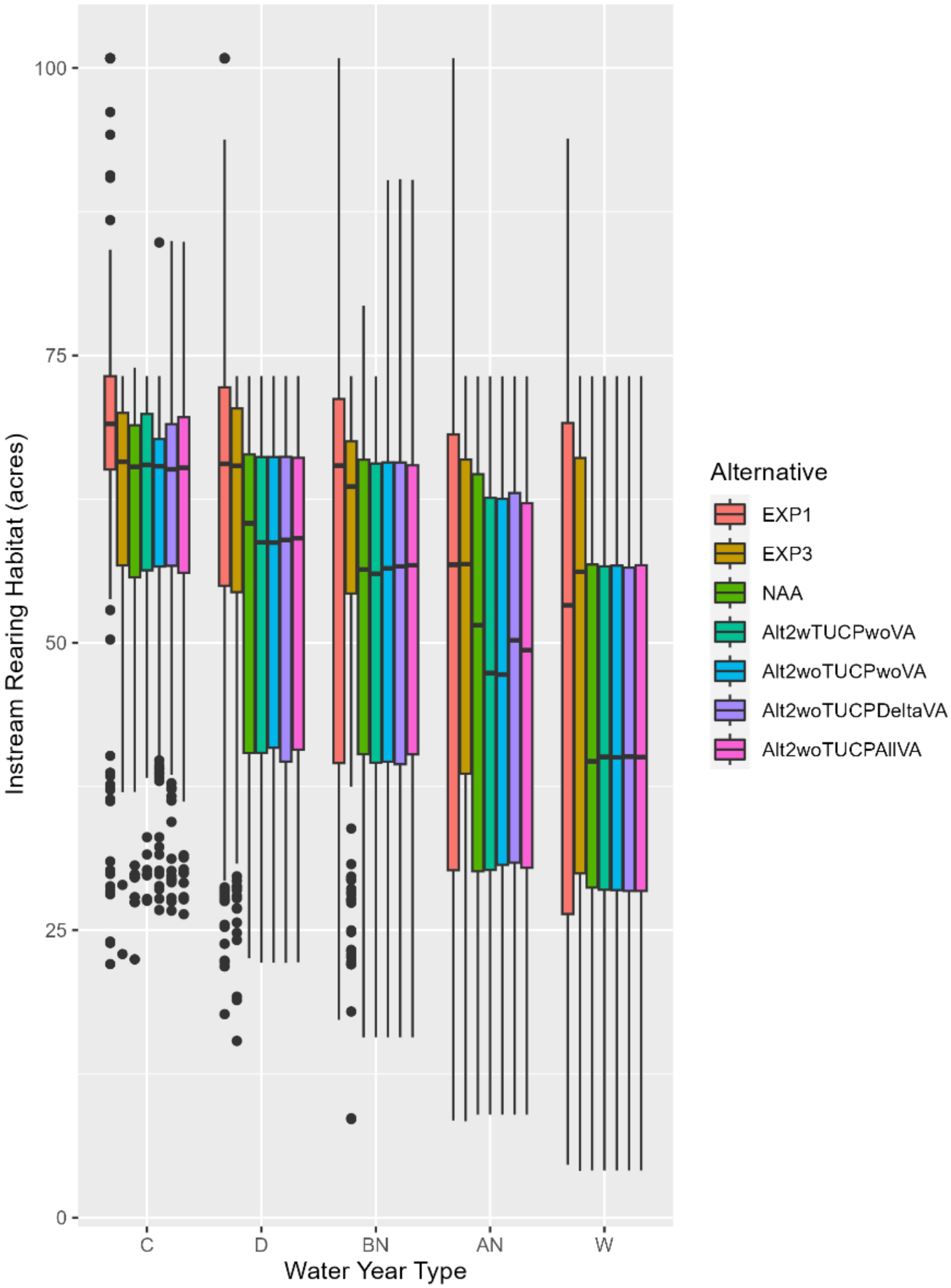
C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-6. Adult Spawning Habitat in the Upper Sacramento River for Steelhead Across Water Year Types for the Biological Assessment Alternatives



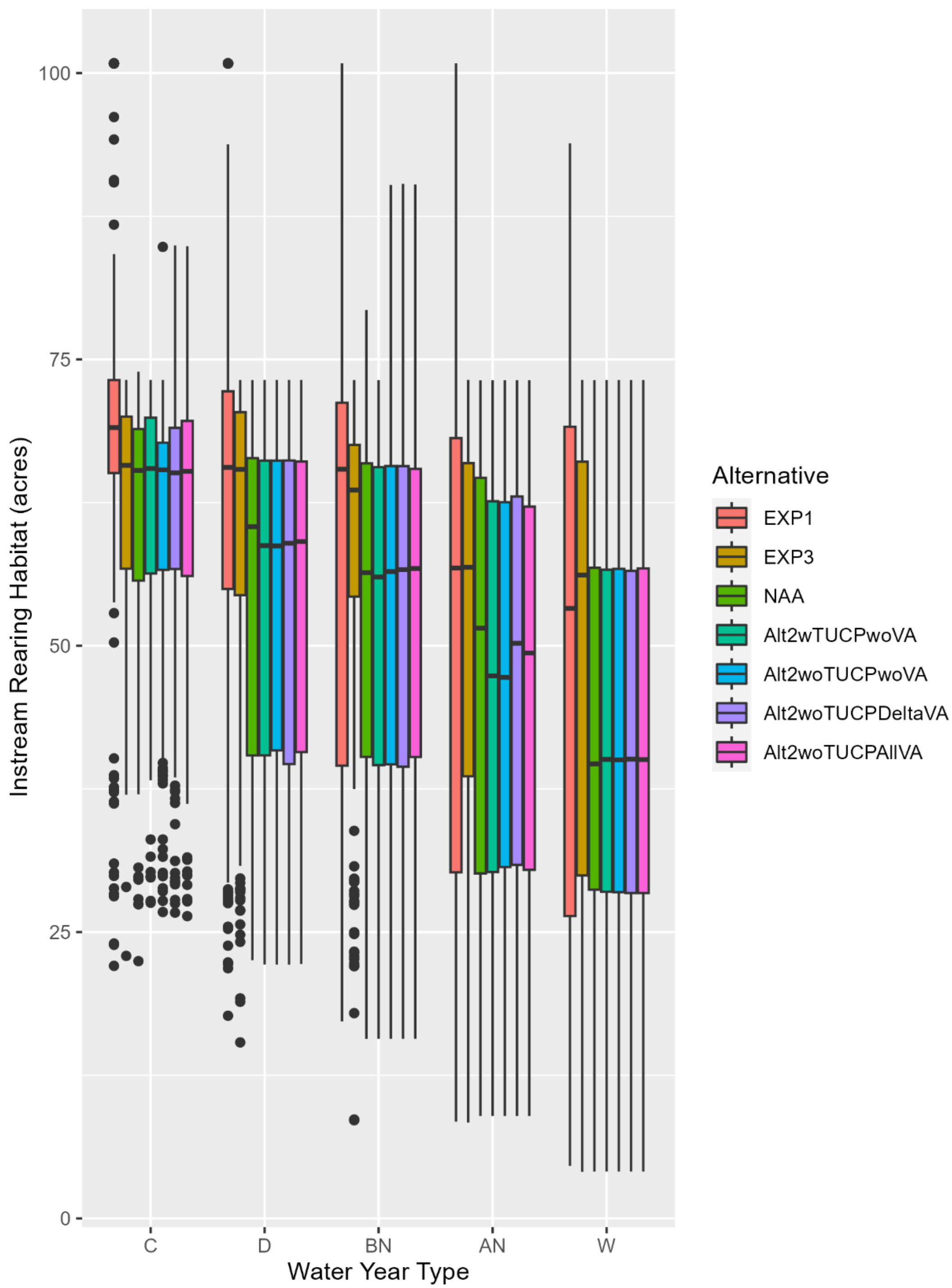
C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-7. Instream Rearing Habitat in the Sacramento River for Winter-run Chinook Salmon Across Water Year Types for the Biological Assessment Alternatives



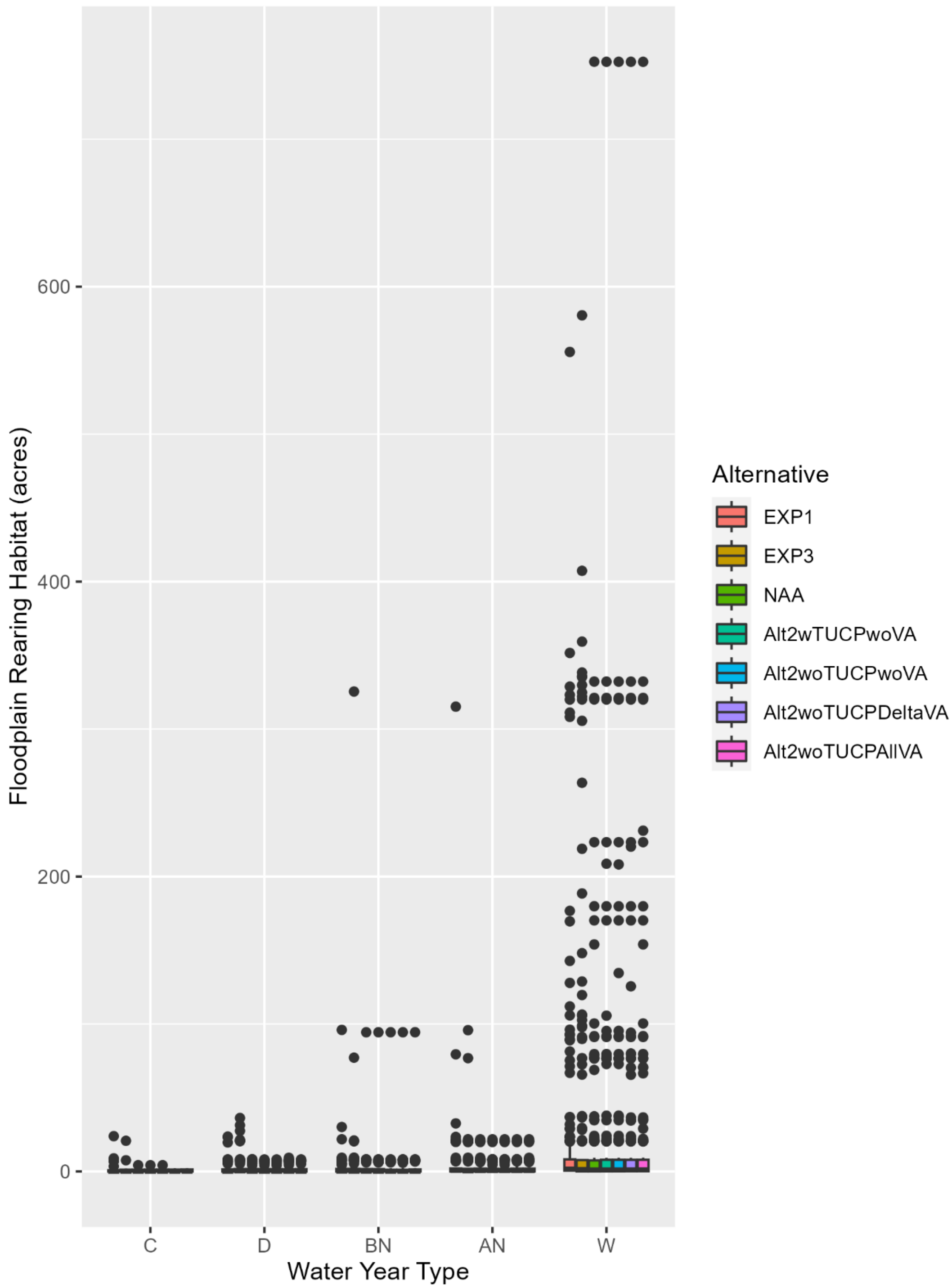
C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-8. Instream Rearing Habitat in the Sacramento River for Spring-run Chinook Salmon Across Water Year Types for the Biological Assessment Alternatives



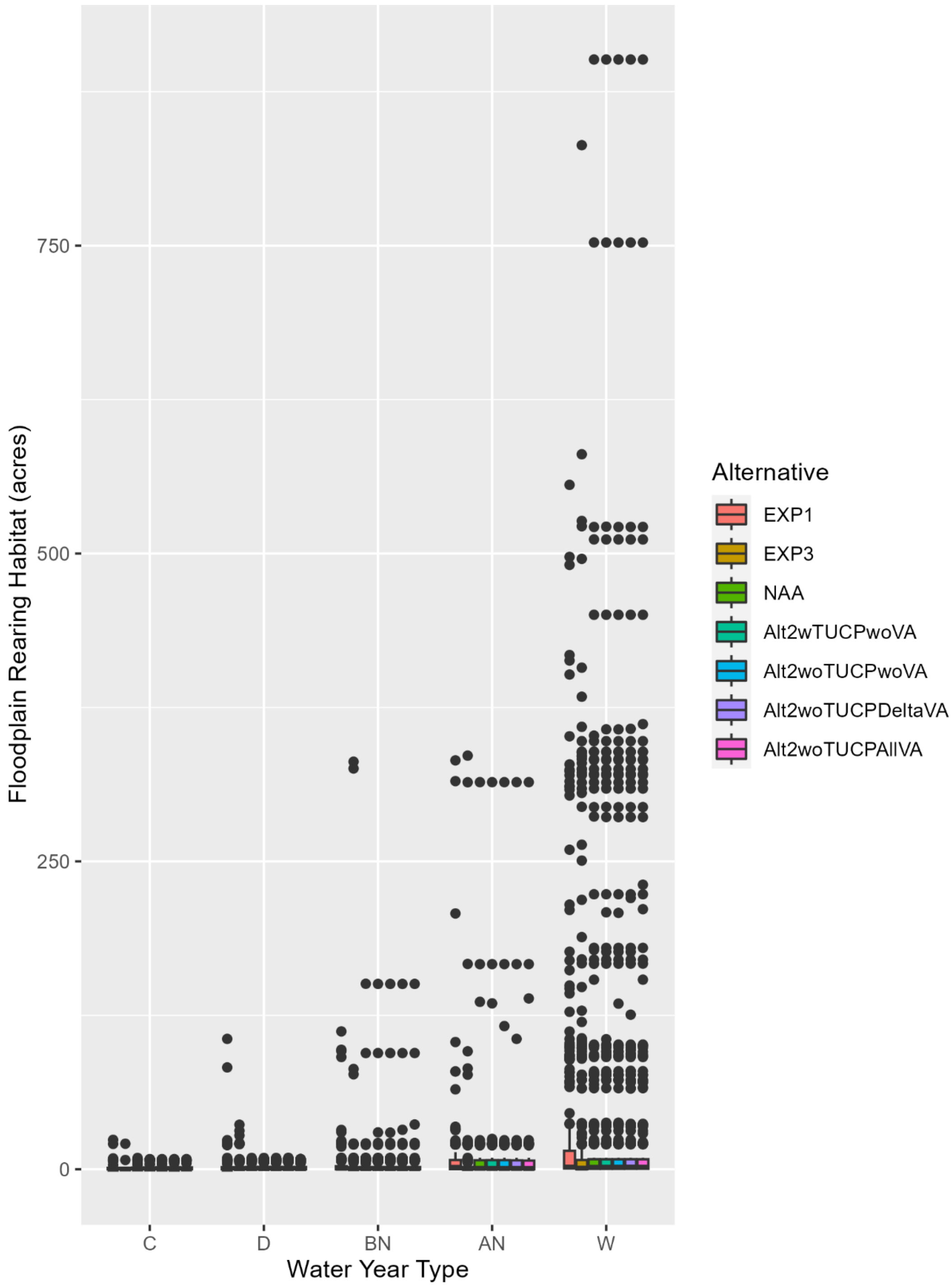
C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-9. Instream Rearing Habitat in the Sacramento River for Steelhead Across Water Year Types for the Biological Assessment Alternatives



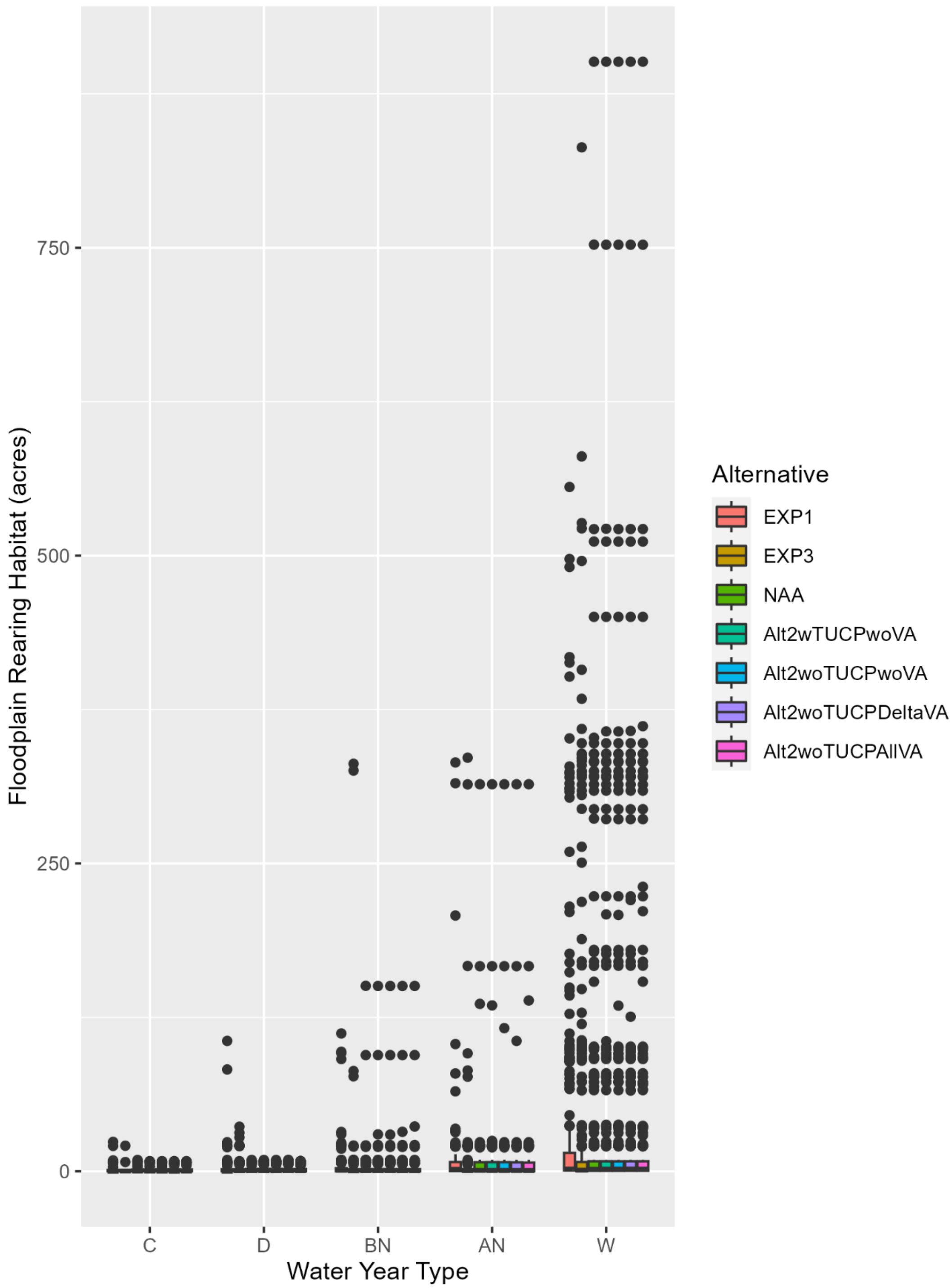
C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-10. Floodplain Rearing Habitat in the Sacramento River for Winter-run Chinook Salmon Across Water Year Types for the Biological Assessment Alternatives



C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

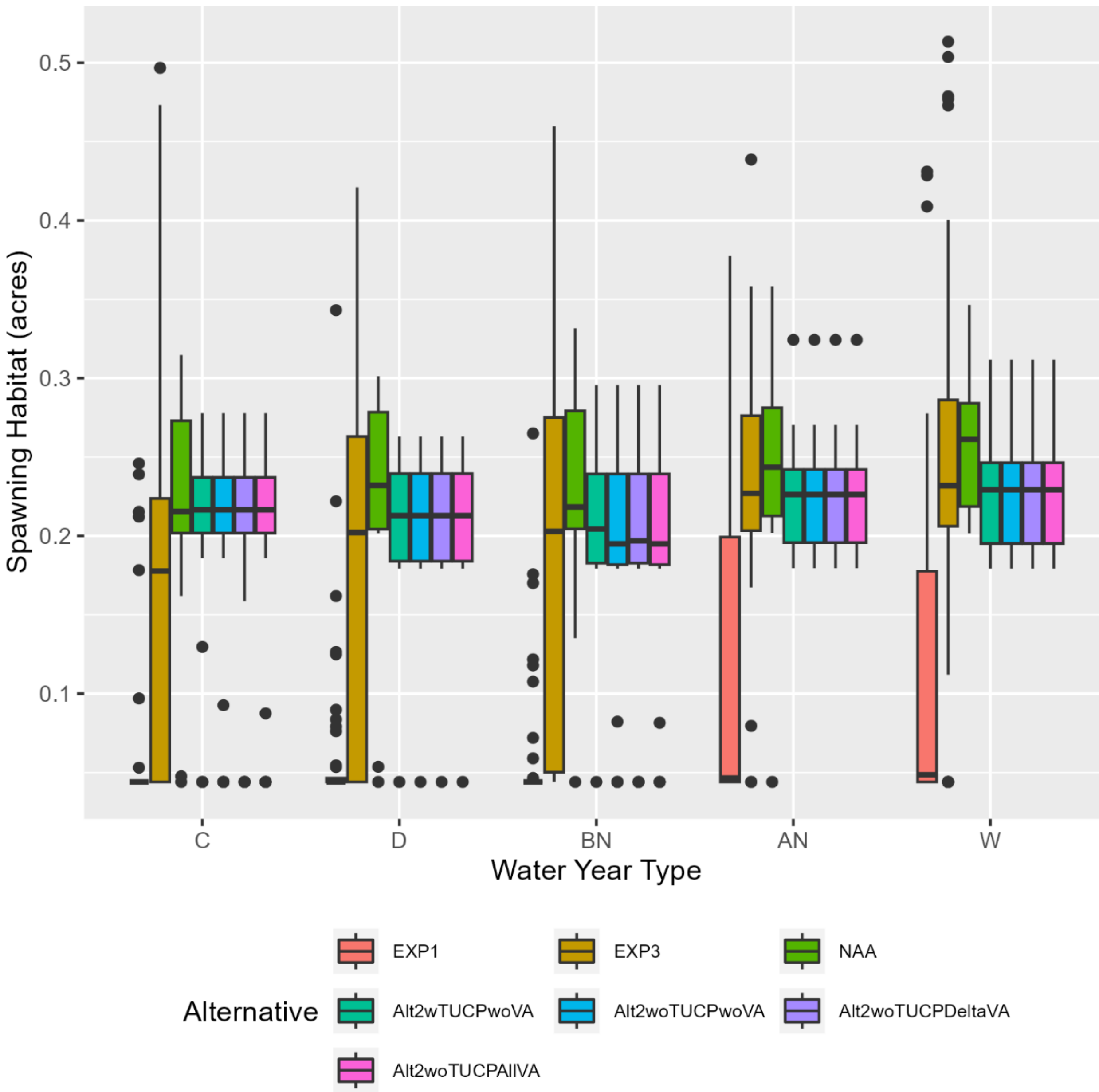
Figure O-11. Floodplain Rearing Habitat in the Sacramento River for Spring-run Chinook Salmon Across Water Year Types for the Biological Assessment Alternatives



C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

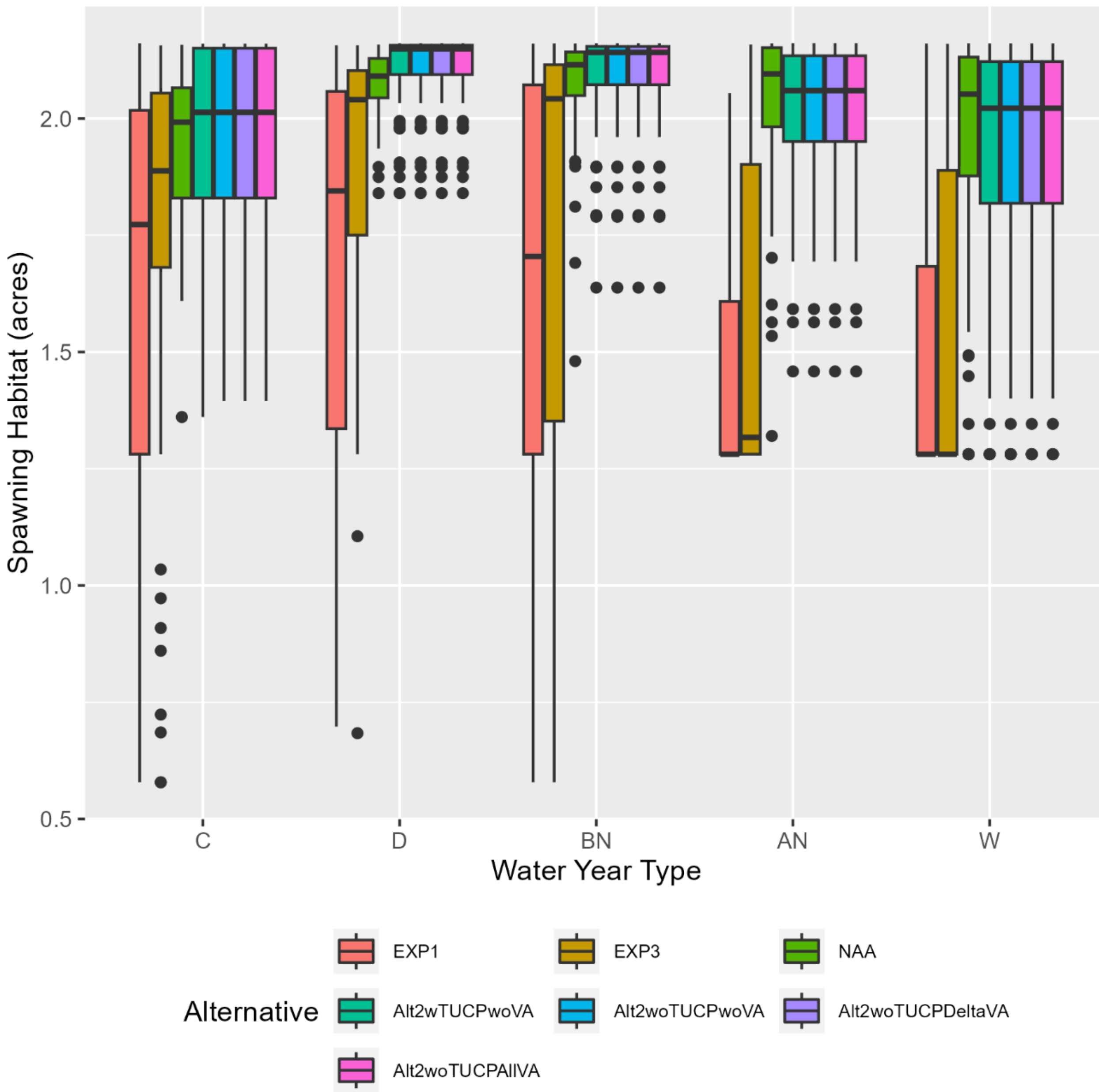
Figure O-12. Floodplain Rearing Habitat in the Sacramento River for Steelhead Across Water Year Types for the Biological Assessment Alternatives

Clear Creek



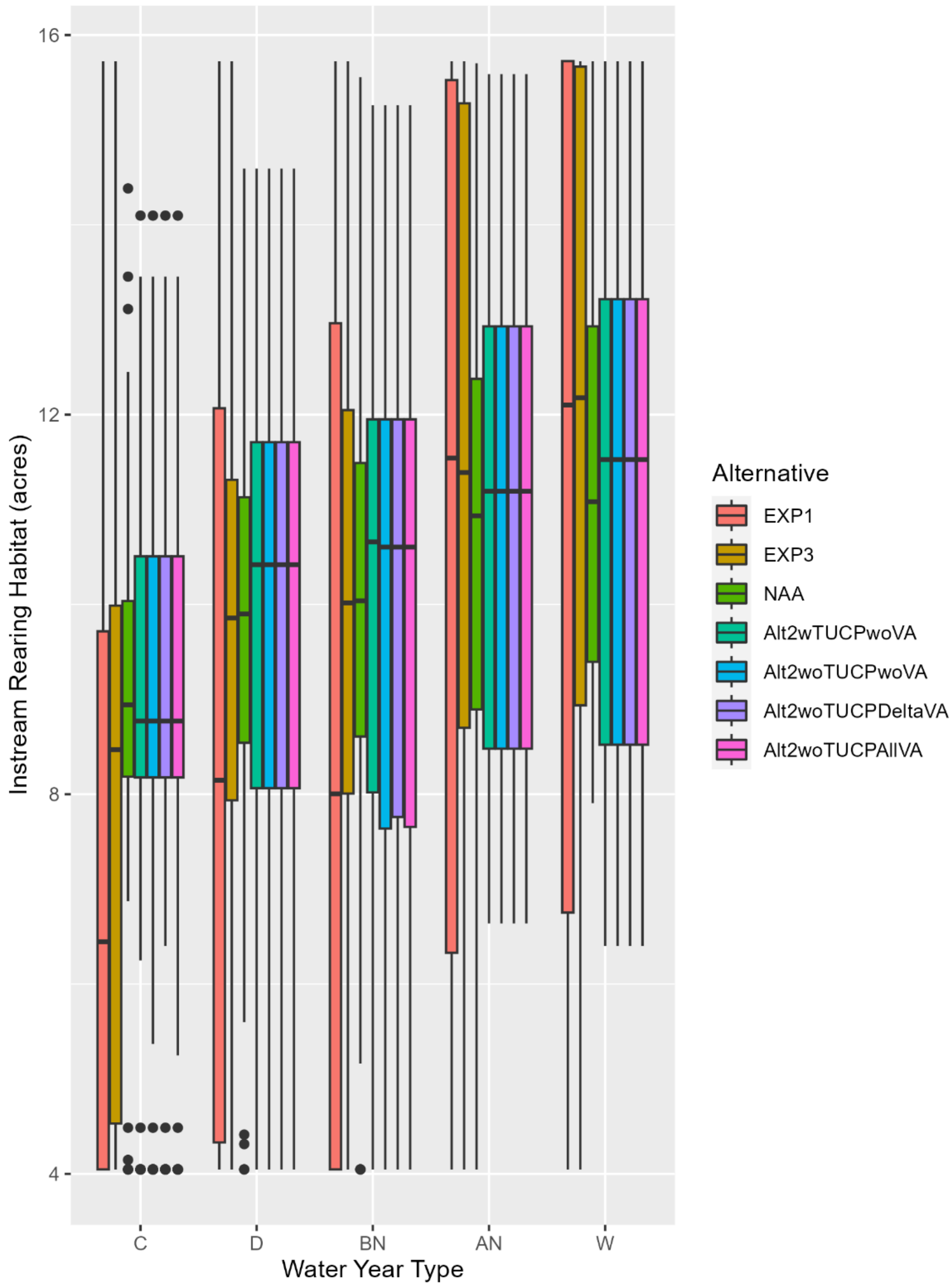
C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-13. Adult Spawning Habitat in Clear Creek for Spring-run Chinook Salmon Across Water Year Types for the Biological Assessment Alternatives



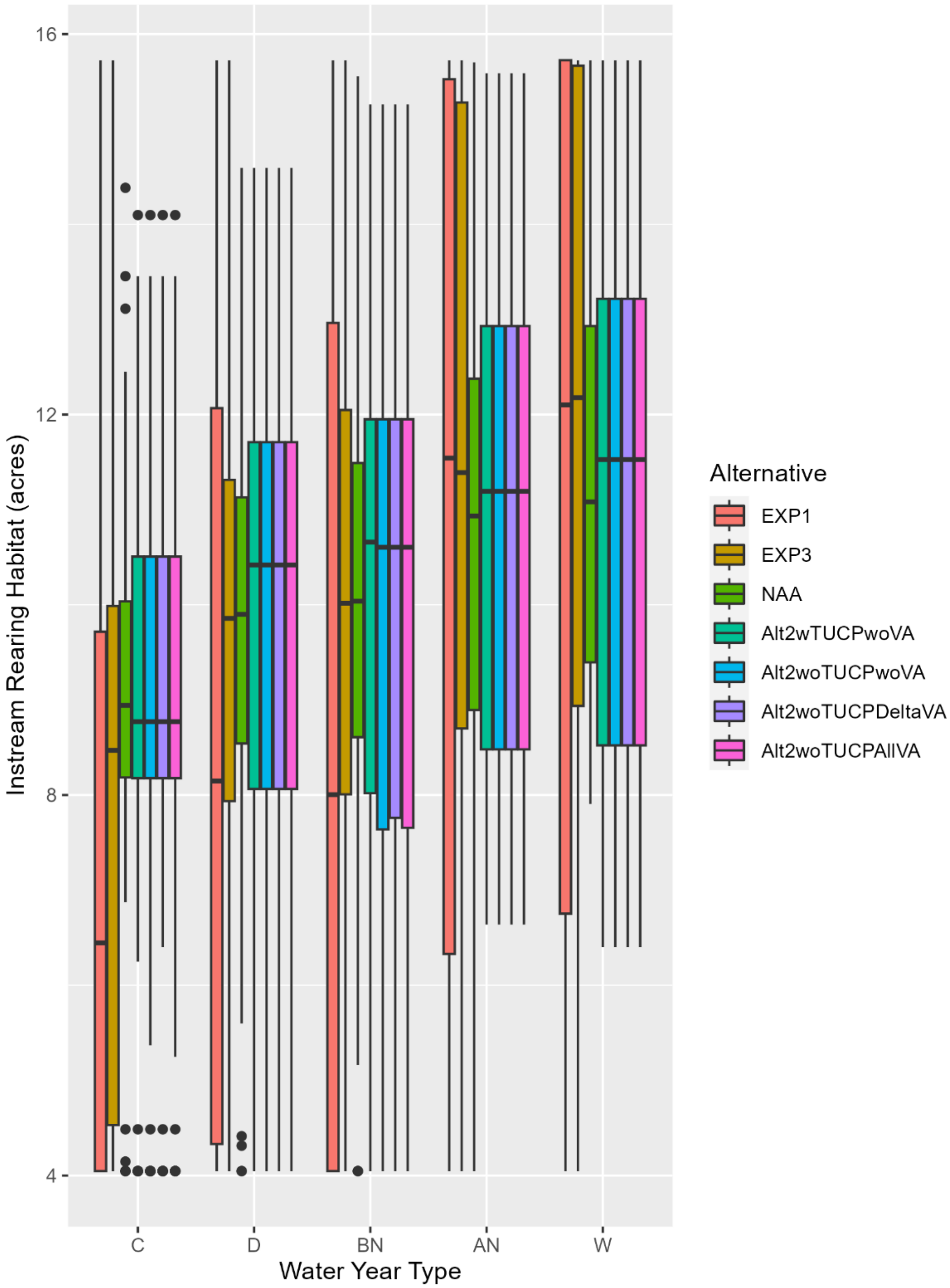
C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-14. Adult Spawning Habitat in Clear Creek for Steelhead Across Water Year Types for the Biological Assessment Alternatives



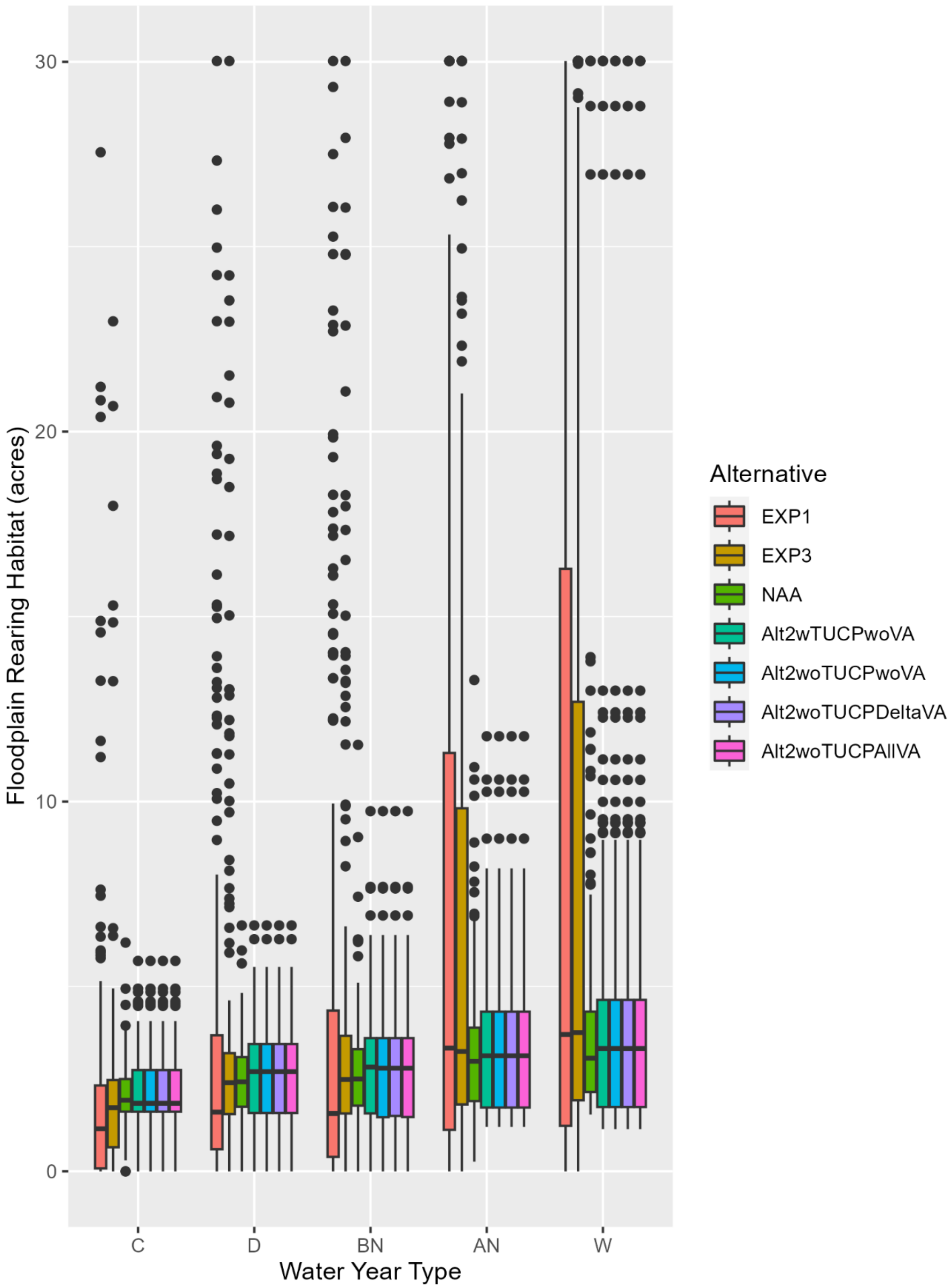
C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-15. Instream Rearing Habitat in Clear Creek for Spring-run Chinook Salmon Across Water Year Types for the Biological Assessment Alternatives



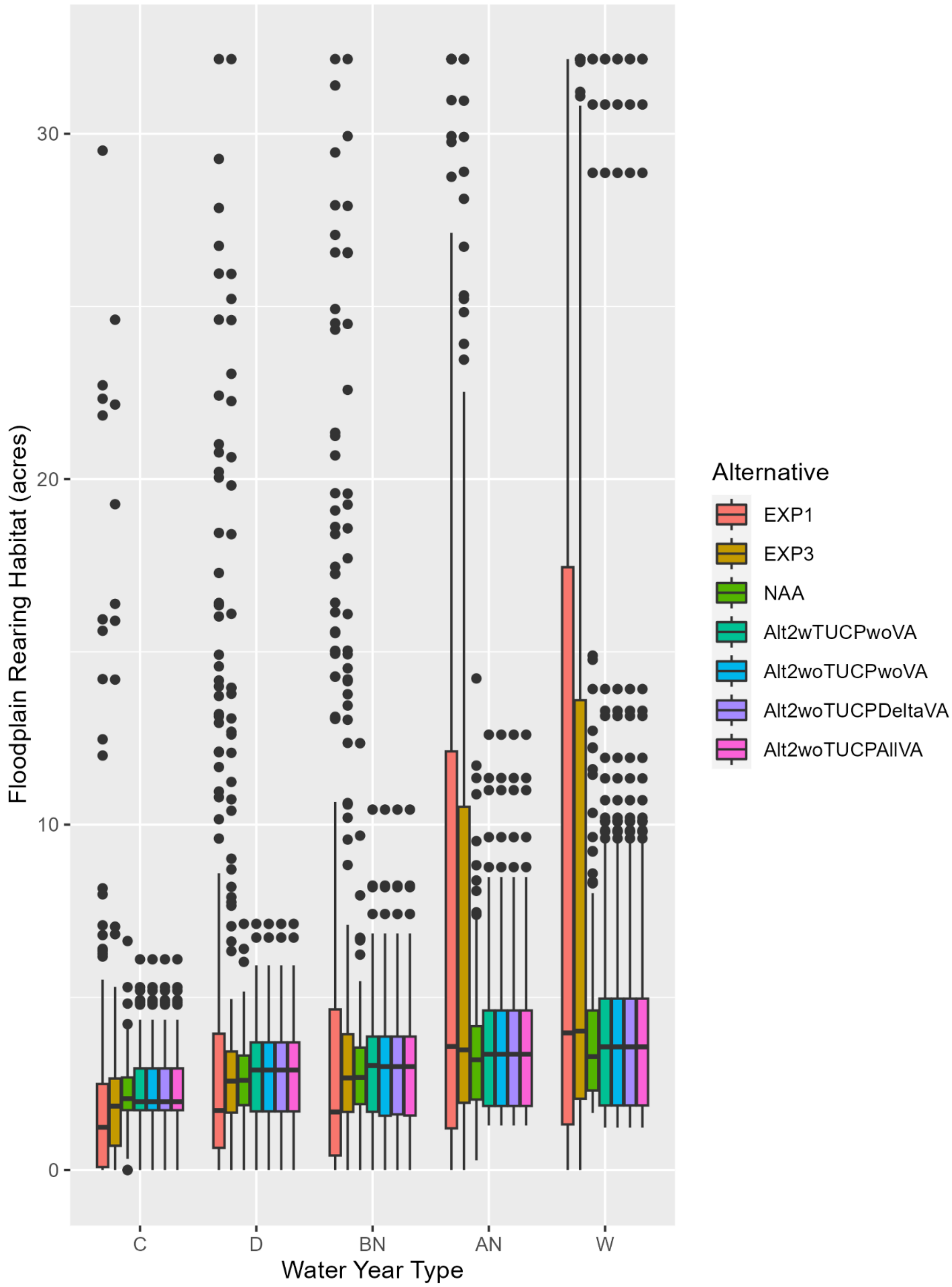
C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-16. Instream Rearing Habitat in Clear Creek for Steelhead Across Water Year Types for the Biological Assessment Alternatives



C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

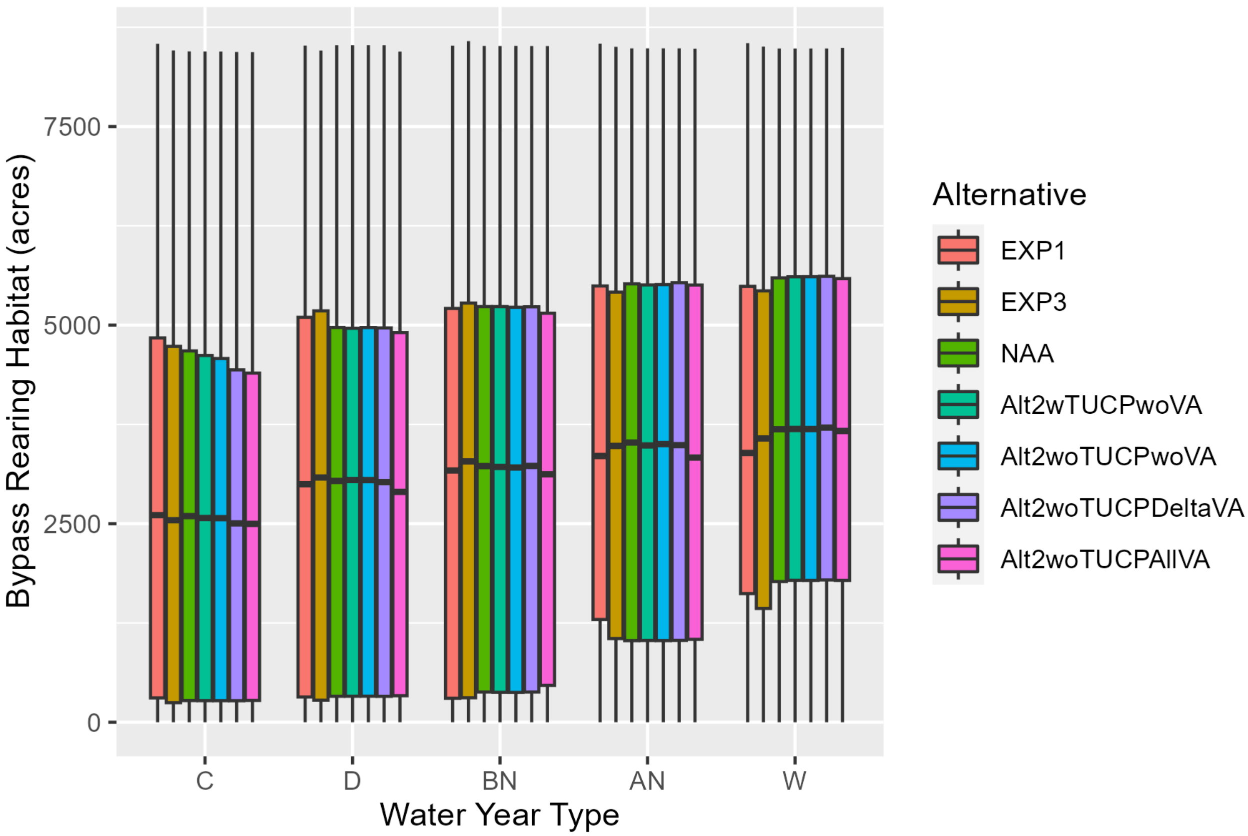
Figure O-17. Floodplain Rearing Habitat in Clear Creek for Spring-run Chinook Salmon Across Water Year Types for the Biological Assessment Alternatives



C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-18. Floodplain Rearing Habitat in Clear Creek for Steelhead Across Water Year Types for the Biological Assessment Alternatives

Yolo and Sutter Bypasses



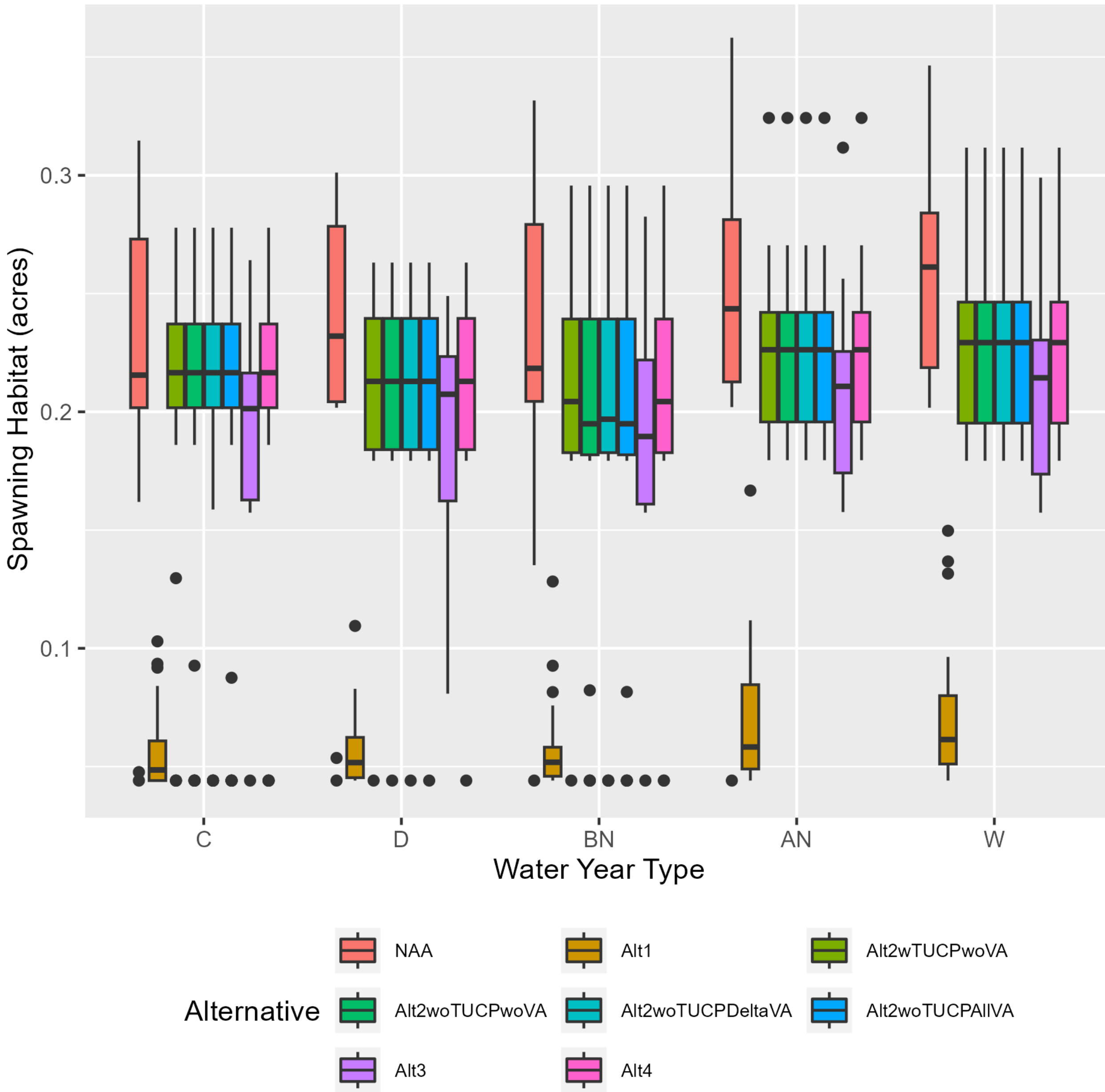
C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-19. Bypass Rearing Habitat in Yolo and Sutter Bypasses for Juvenile Salmonids Across Water Year Types for the Biological Assessment Alternatives

O.5.2.2 Environmental Impact Statement Results

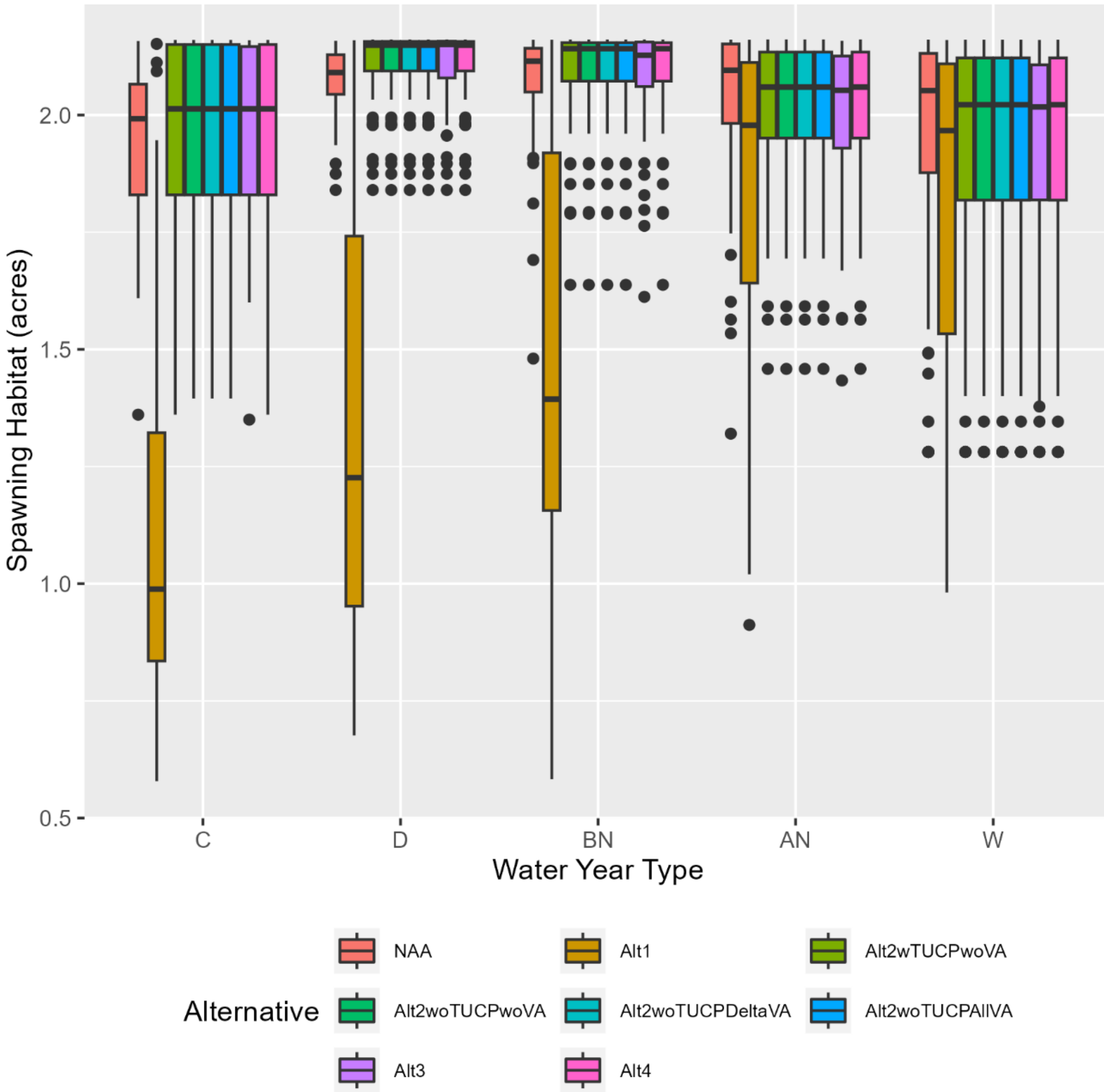
Sacramento River

Clear Creek



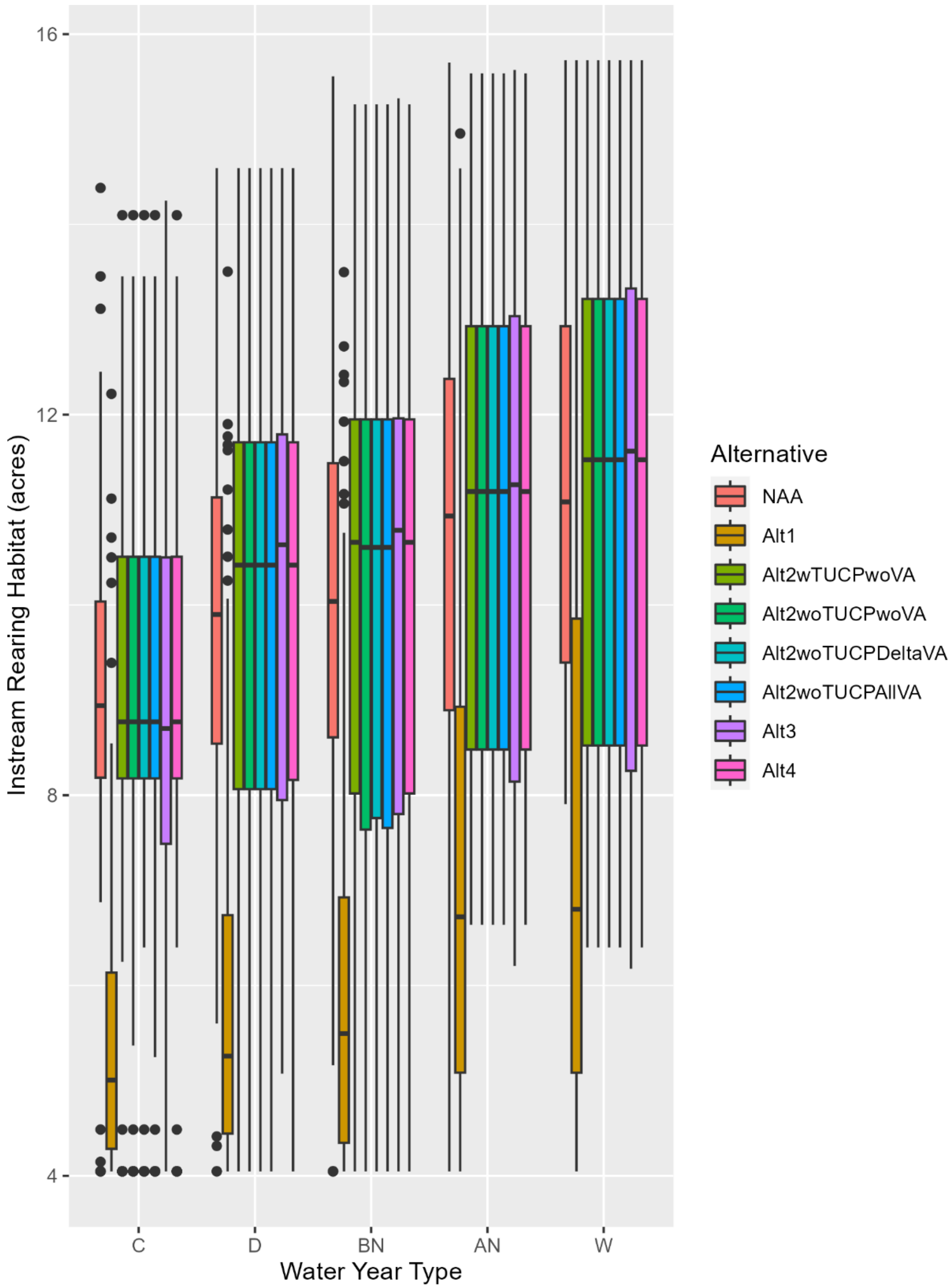
C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-20. Adult Spawning Habitat in Clear Creek for Spring-run Chinook Salmon Across Water Year Types for the Environmental Impact Statement Alternatives



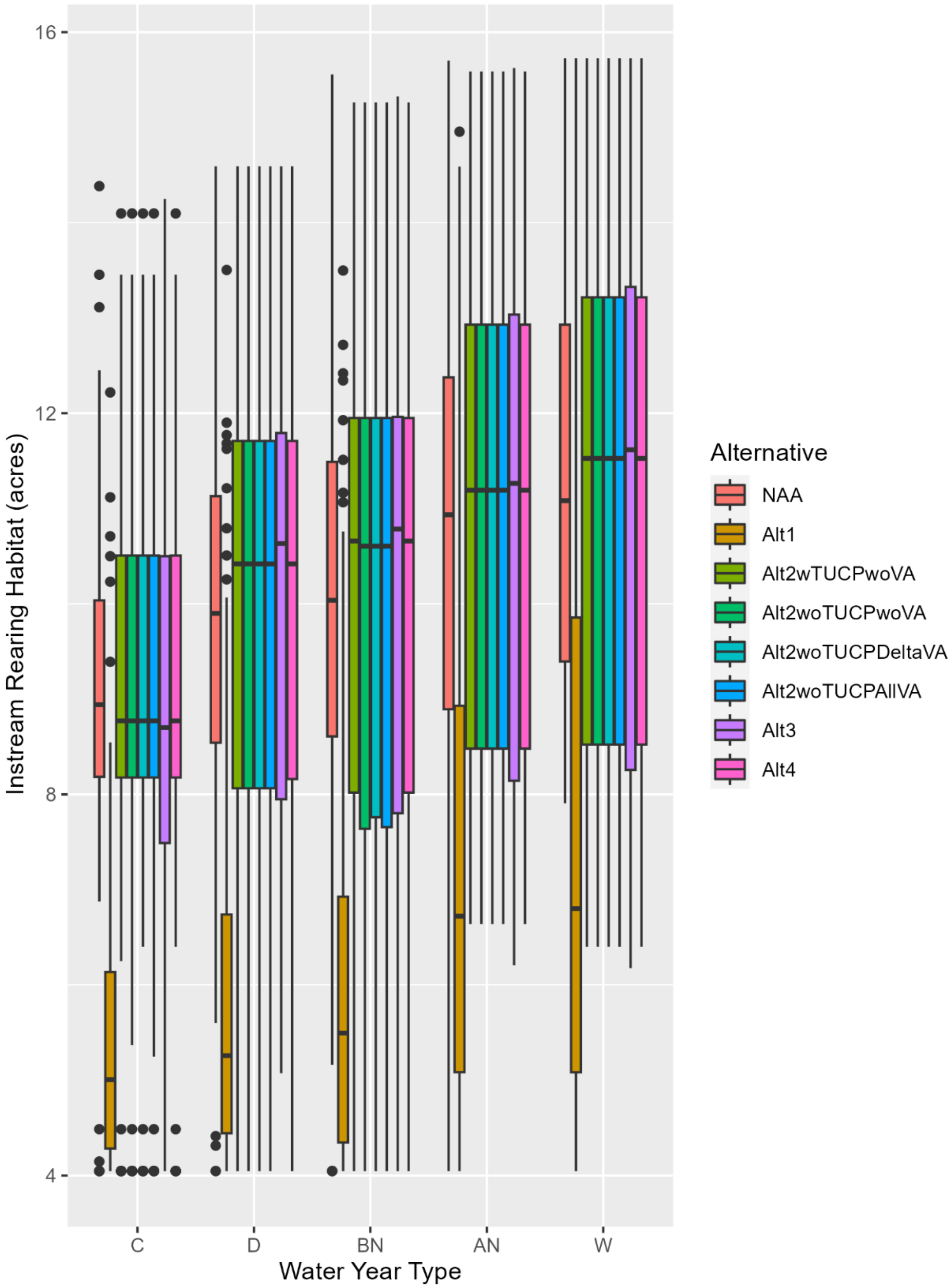
C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-21. Adult Spawning Habitat in Clear Creek for Steelhead Across Water Year Types for the Environmental Impact Statement Alternatives



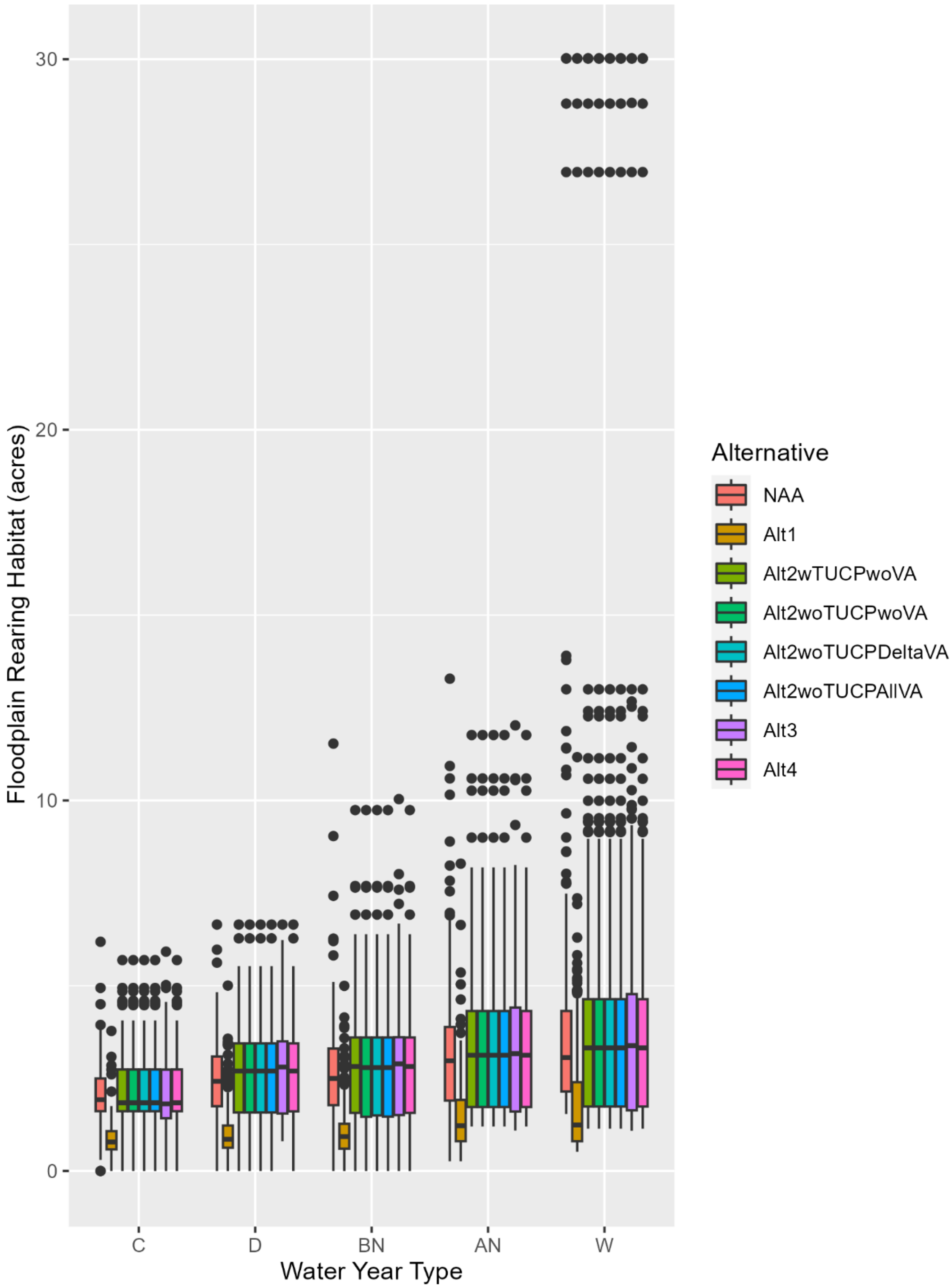
C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-22. Instream Rearing Habitat in Clear Creek for Spring-run Chinook Salmon Across Water Year Types for the Environmental Impact Statement Alternatives



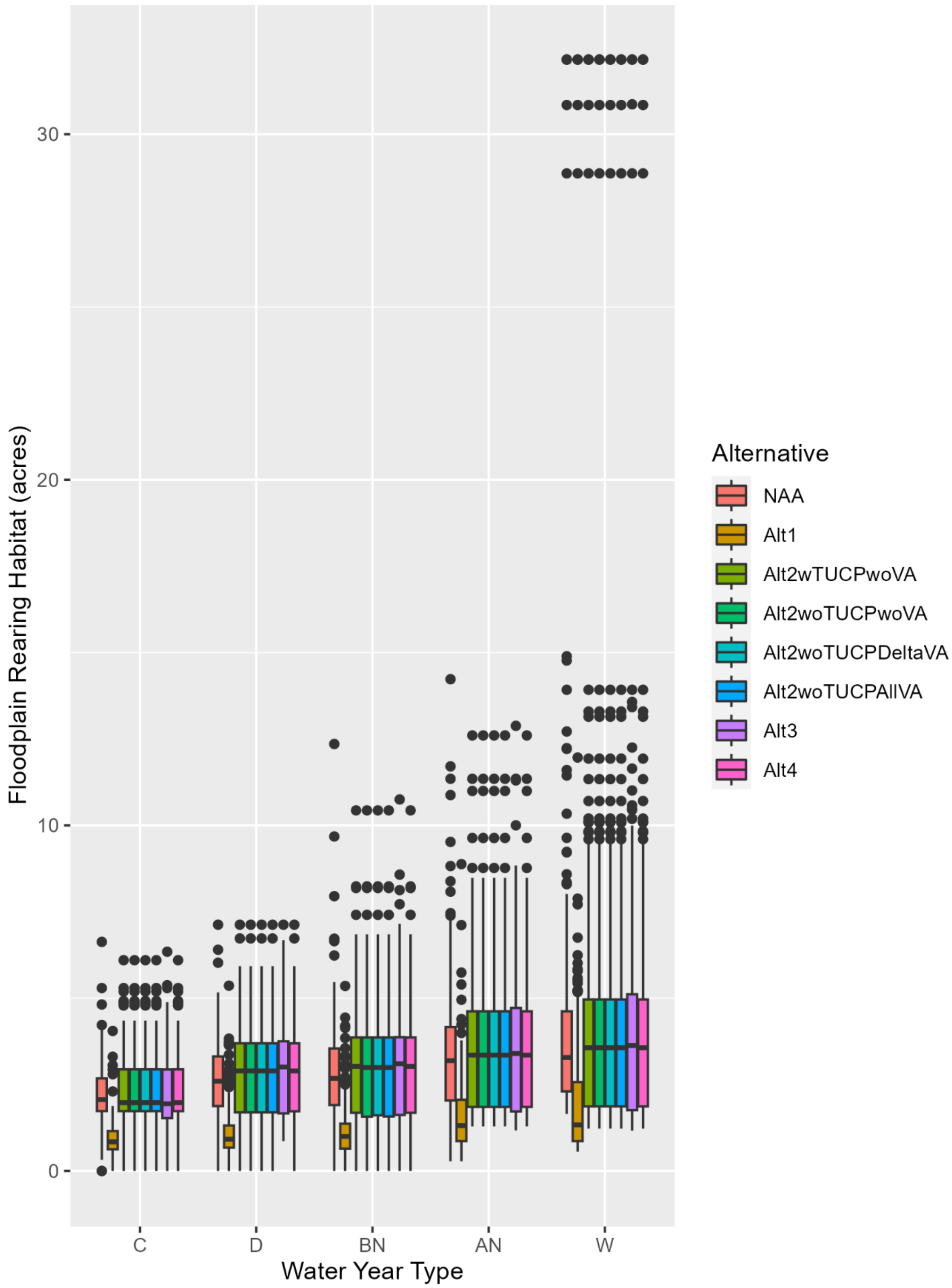
C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-23. Instream Rearing Habitat in Clear Creek for Steelhead Across Water Year Types for the Environmental Impact Statement Alternatives



C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

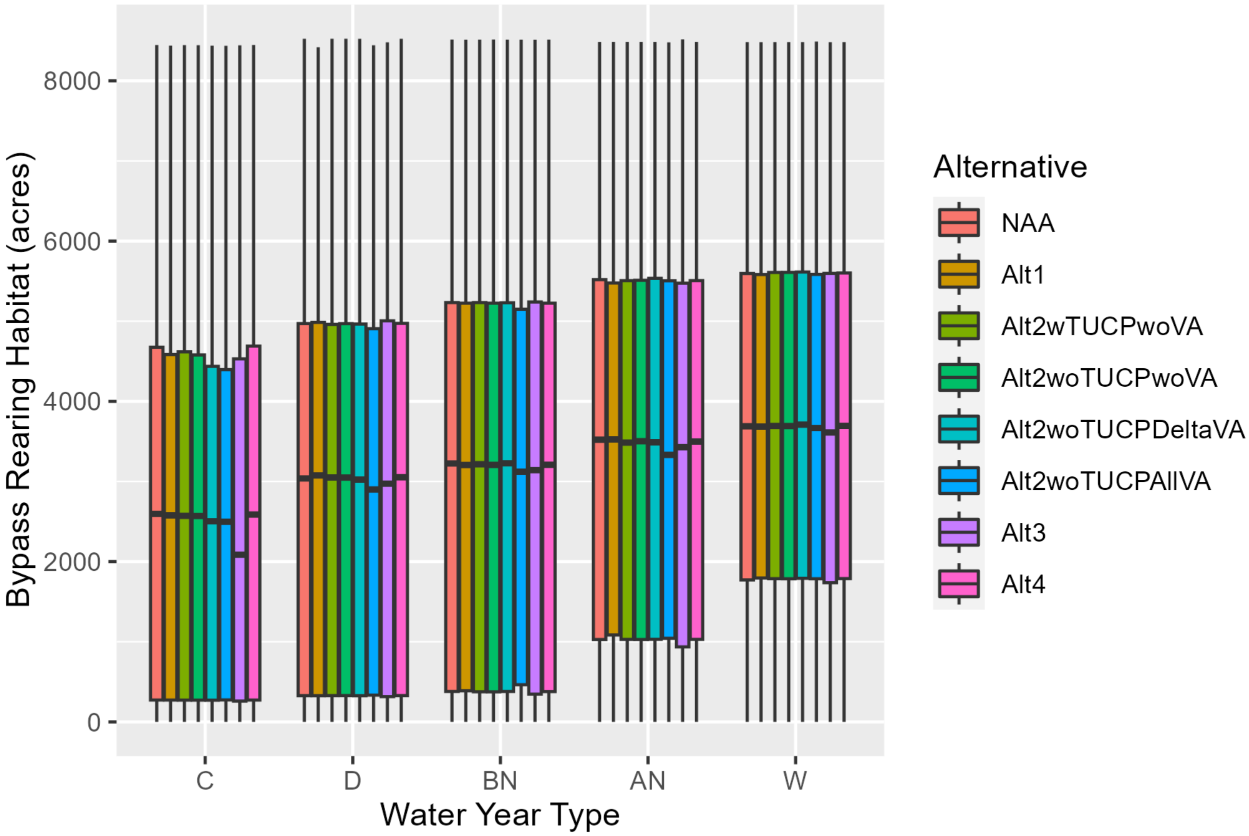
Figure O-24. Floodplain Rearing Habitat in Clear Creek for Spring-run Chinook Salmon Across Water Year Types for the Environmental Impact Statement Alternatives



C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-25. Floodplain Rearing Habitat in Clear Creek for Steelhead Across Water Year Types for the Environmental Impact Statement Alternatives

Yolo and Sutter Bypasses



C = critically dry; D = dry; BN = below normal; AN = above normal; W = wet.

Figure O-26. Bypass Rearing Habitat in Yolo and Sutter Bypasses for Juvenile Salmonids Across Water Year Types for the Biological Assessment Alternatives

O.6 Uncertainty

Hydrodynamic and water quality effects of tributary restoration on refuge habitat and food quantity and quality stressors are well documented. Habitat restoration monitoring lacks mechanistic models to explain individual effects on fish from these restoration actions. Uncertainty remains around how individual effects on survival and growth, from tributary habitat restoration, may affect Endangered Species Act (ESA) listed species populations.

Special studies of high value that may reduce uncertainty about the effectiveness of tributary habitat restoration for ESA listed salmonids include:

- Tributary Habitat Restoration Effectiveness for salmonid fishes

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